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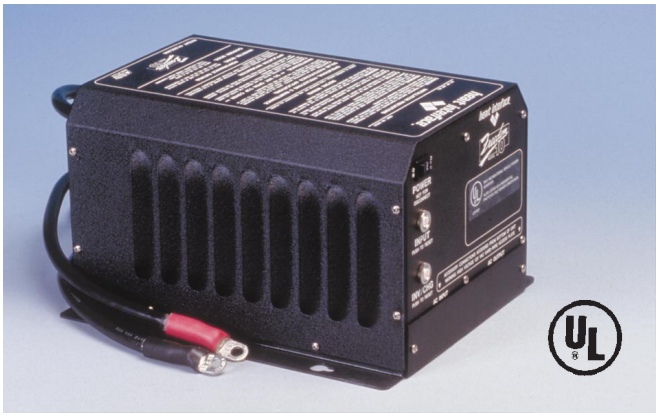

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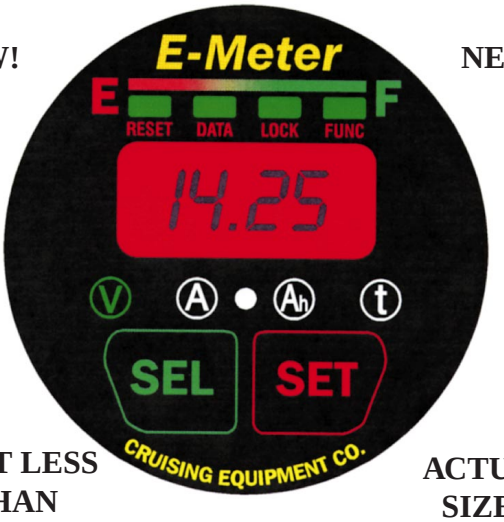

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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #47 June / July 1995

Features

GoPower

Fundamentals

Cover: The view from the top! This 2.5kW Jacobs wind generator is a fifty year old ancestor to the one powering Shawn Otto's wind/utility system on page 6. Photo by Windy Dankoff, shot near Santa Fe, New Mexico in 1970

Homebrew

Things that Work!

Columns

Regulars

Access and Info

Access Data

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Recycled Paper

Recyclable Paper

Photo by Bart Orlando

Have you ever felt alone?
The best cure for the lonesome blues is a quick pump-em-up on the Human Energy Converter (HEC). Check out the happy faces pedaling power for this year's Renewable Energy Fair in Arcata, California. Bart Orlando's HEC not only makes electricity, but also gives energy and joy to each pumping HECler. The HEC has become a symbol for all of us pushing together for renewable energy.

It's easy to feel isolated in our search for a clean renewable future. Renewable energy, and the ideas behind it, are still new concepts for many. Most of us home power types have the only renewable energy system in the neighborhood. One of our goals here at Home Power is to bring us together.

In this issue of Home Power alone we can easily see how renewable energy is spreading across America. On page 6, Shawn Otto tells of placing his wind power back on his local utility grid. The local powers that be didn't make it easy for Shawn, but he persisted and was successful. The problems Shawn faced weren't technical, but social and political. We've got piles of great RE hardware. We know how to hook-up this hardware in long-lasting, efficient energy systems. We're ready, but society is still stuck in what I call a "combustion" mentality. Once again, technology has outpaced society's ability to cope with it.

I salute the energy pioneers everywhere. Keep on putting up PV modules. Put up those wind generators. Install that new micro hydro. Make your home an independent energy exporter. And if you are grid-connected, offer your surplus power to your local utility. Let them know where your power comes from. Let them know they can become renewable too.

Richard Perez for the Home Power Crew

People

Sam Coleman
Michael Hackleman
Jon Haeme
Conrad Heins
Kathleen Jarschke-Schultze
Sue Ellen Kingsley
Terry Kinzel
Stan Krute
Don Loweburg
Harry Martin
Kurt Nelson
Bart Orlando
Shawn Otto
Mark Parthe
Karen Perez
Richard Perez
Shari Prange
Mick Sagrillo
Bob-O Schultze
Michael Welch
John Wiles
Donna Worden

" Think about it… "

"People think love is an emotion. Love is good sense."

—Ken Kesey

SOLAR DEPOT

full page bled
four color on negatives

This is page 5

Above: South view of our super-insulated, passive solar home in process, with the big Jacobs in the background.

Turbulence: Wind power, zoning, and the 90's

Shawn Otto

Our place is named Breezy for a reason. The wind blows and blows here, which is, well, sort of unique for this small eastern Minnesota community near the banks of the St. Croix River. A lot of people have old rickety, rusty water pumpers that have long ago become relics, nestled in a grove of mature elms, overgrown with ivy, debladed and nude. These things stand as crusty emblems of country life in Minnesota. But they are only emblems. Few folks in our area have wind generators, the newer, sleeker, beefier cousins of these old farm hands, and that's as good a place as any to begin this tale of renewable energy and what to watch out for with your windy dream.

A healthy fever

A little over a year ago, Rebecca and I finally closed on our ideal parcel, 30 rolling, grassy acres abutting ponds and wetlands in May Township, Minnesota, about 35 minutes northeast of the Twin Cities and a stone's throw from Big Marine Lake. We picked a spot with a good south-facing hill to berm into. We designed a superinsulated, passive solar-assisted home with an insulated slab, hydronic heating tied into a masonry

wood heater, and super-efficient appliances. Even before we began building, we would take long, slow walks out in the natural prairie grasses, wading through them, listening to them whisper and spit, and we began to notice that they were almost never still. The wind was almost always blowing. For people who think like we do, the next idea was a simple step in logic—wind power. We didn't realize what a huge leap we had just made, but our feet were already in mid-air, committed.

Innocently, we went boldly forward. It would cost about $3,500 for our electrical cooperative, Anoka Electric, to bring power up our 1/3 mile driveway. This would cost about half as much as a good battery bank. With a utility intertie wind system, we could use the utility as our battery bank and maybe even provide excess power. Minnesota is a net energy billing state, so Anoka would pay us the same 7 cents per kWh they charge. After a good deal of common sense research, we decided that, dollar-for-dollar, buying a used Jacobs 10 kW Machine from Mick Sagrillo at Lake Michigan Wind & Sun was our best value, at about half the cost of new. It was either that or the 10 kW Bergey, which requires much less maintenance. We wanted a payback period in our lifetime, and I didn't mind the idea of climbing the tower and greasing up the bearings twice a year, as a kind of sacrament. In the end, we bought a machine Home Power readers have seen before - it was featured on the cover a few issues back, as the demo at the 1994 Midwest Renewable Energy Fair (MREF) in Amherst, Wisconsin. It's also the first wind tower Karen Perez ever climbed, I heard on good authority.

So far, so good...

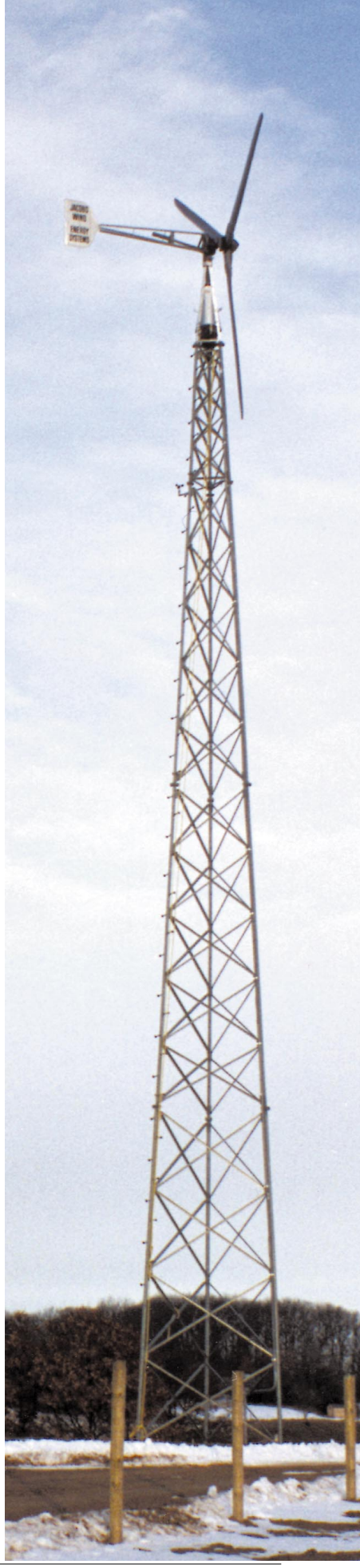
So far, everything was a cinch. Dig the holes, pour the footings, stand up the tower, and bolt the generator to the top. The only complexity was a formality—our township had a height ordinance that required a conditional use permit for structures over 35 feet high. No big deal, though, since this was a rural area and there were plenty of water pumpers, barns, and old silos higher than that. Think again!

At our first public hearing, two neighbors showed up who were dead set against our tower. The commissioners' faces became hesitant, their eyes focused inwardly on questions of liability, litigation, and precedent. They became concerned that if they let us go ahead, somehow wind generators would suddenly proliferate, popping up all over the township, as if that were a bad thing, and that some kind of ordinance was needed to control this. The "evil neighbors," as we came to call them, played to these sentiments, painting wind generators as horrible, dangerous, bird killing, noise polluting, aesthetically grotesque, property value detracting attractive nuisances that, besides all that, just plain didn't work. The planning commission balked and tabled the matter pending research and development of an ordinance governing wind generators.

In many rural communities, this kind of scenario would seem somewhat ridiculous. This is America, and you've got the right to do whatever you want to as long as it doesn't infringe on your neighbors' rights to do the same. But in the area where the greatest growth in interest in renewable energy exists—small acreage hobby farming communities near major metropolitan areas—things are getting too constrictive. Neighbors are closer, less trusting, and more likely to seek control over each other's activities. This suggests a need for a whole new set of zoning laws addressing cogenerated and stand-alone renewable energy systems.

Research is Power

Reasoning that our problem was not unique, we contacted several professionals in the wind energy business. Universally, we felt exasperated with what were,



indeed, increasingly common circumstances. Unfortunately, examples of ordinances or even anecdotal stories of how these problems were solved was lacking. We did run into one couple from Wisconsin at MREF'94 who had a zoning horror story that lasted three years, ending with a permit granted with severe restrictions. As our process progressed, it began to look like this could happen to us, also. One of the board members commented at the third meeting that by the time they got done adding conditions, the only place we would be able to erect our generator would be in a cave.

The "evil neighbors" were grumpily traipsing forward every month with new angles and new research on how wind machines would be a bad thing, or how they should be required to be placed only in the geographic center of lots at least forty acres in size (wonder how they arrived at that number?), or how they should be nowhere near wetlands because of the birds, or how they sounded like helicopters, or how they should be required to have trees planted around them to screen them from view. Our approach was to present both sides of the facts clearly, to out-research our "evil neighbors" (which was easy with *Home Power* and *Wind Power for Home and Business*, by Paul Gipe), and to remind the townspeople and board members of the values we held that made this so important to us. Slowly, reason began to prevail and the board grew irritated with the constant and transparent tirade conducted by our "evil neighbors." Slowly, our amassed research began to influence the formation of the ordinance. Slowly, an important precedent in favor of renewable energy was codified into law in our community. Slowly, good triumphed, and eventually, we were granted a permit to erect our tower.

Looking back on the experience, it is easy to understand the quick exasperation of wind energy dealers with some zoning laws. Many don't account for a wind tower's unique circumstances. On the other hand, the concerns of town and county commissioners about precedent and liability, with little or no body of law to fall back on, are understandable in today's litigious society. Standards are needed to encourage wind energy's safe and effective development within a community. They should act as a guide for wary town boards and city councils who feel they are flying in the dark, have little exposure to the idea of wind generation, and lack informed sources.

Those standards are slowly developing, in the form of local ordinances. To promote reasonable laws, renewable energy advocates need to help educate others in this process. In our case, we were heavily involved in the research and drafting of the eventual ordinance. Had we an example early on, our process could have been greatly foreshortened. We are enclosing a sample ordinance (see sidebar and editor's note) that may be codified in township, city, or county law. It will provide a practical format for fostering the safe and reasonable use of wind energy in our communities.

Here are some common concerns your community board is likely to have about wind energy.

Tower height

Tower height is a key factor in wind generator performance. The rotor arcs have to be at least thirty feet above any objects within 300 feet, including trees, to avoid power-robbing turbulence. *Home Power* has printed several very educational articles by Mick Sagrillo on the physics behind this rule. In short, wind generators come with three relatively standard tower heights: 80 feet, 100 feet, and 120 feet. To simplify, the higher the tower the faster and more powerful the wind, because it's not getting chopped up by terrain, trees, and buildings. Ours is an 80 foot tower, which is a sufficient height for our high, open hill. Most locations require 100 to 120 feet for economic performance. Most people cannot visually perceive the difference between 80 and 120 feet without some reference.

Tower location

The tower should be located within the normal setbacks for structures on your parcel. Towers are typically engineered to standards far superior to homes and tall buildings and can withstand severe winds - in excess of 100 mph - with no damage. Statistically, trees are far more likely to fall and your roof more likely to blow off. This is what you have insurance for. Your municipality, however, will likely still err on the conservative side, requiring the tower to be located at least its own height away from all lot lines. This is called the "fall zone" of the tower.

Tower safety and access

There are competing arguments on the issue of safety. One side says: somebody might climb it and fall off ("attractive nuisance") so you should fence it to deter that. There are eight arguments against this idea. One, the fence is as much if not more of an attractive nuisance as the tower. Two, if somebody decides to climb an 80 foot tower, a six foot fence isn't going to stop them. This is our position, which made sense to our township and county boards.

Three, in our case, the tower is located several hundred feet away from the road. A person would have to trespass pretty heavily just to find the base of the tower. Four, even if someone *did* find the base, the bottom twelve feet of rungs will be removed, making

Top Left: Tower base showing base junction box and required signage

Bottom Left: Some massive footings - 6 yards of concrete piers reinforced with 1" rebar each tied into a 2' x 5' x 5' pad buried at eight feet. The angle iron bases are held in place by this wood template while the concrete sets.

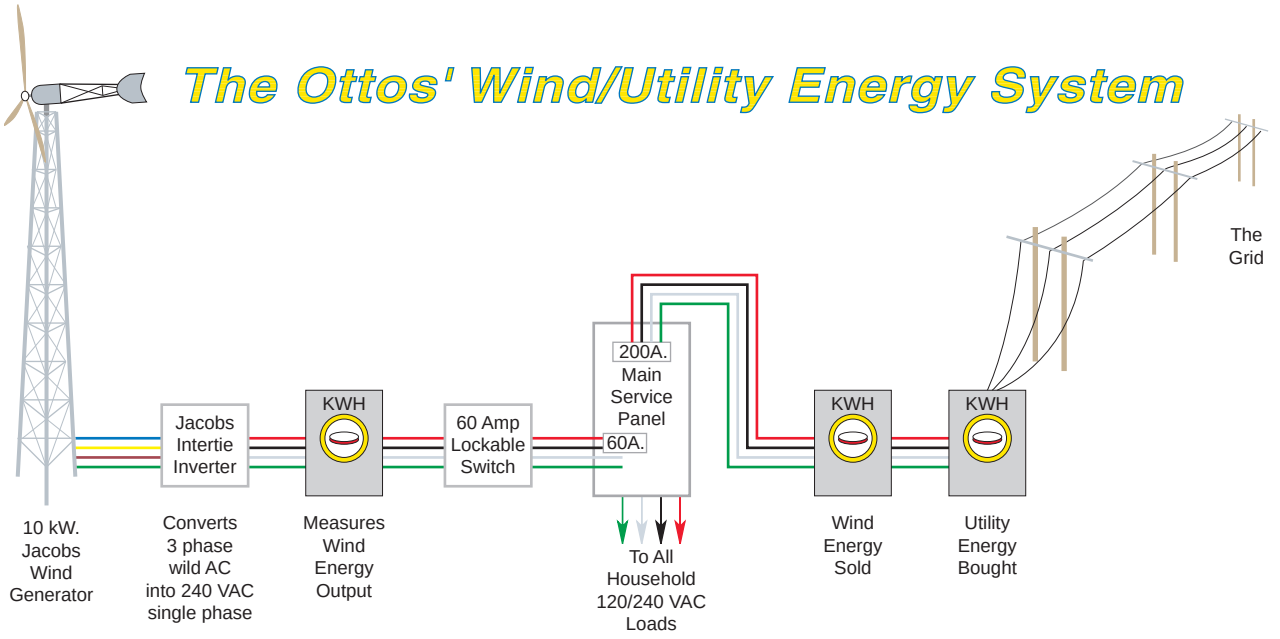
Above: One of the three tower footings up close.

the tower difficult to climb. Five, the tower will be posted with a sign stating: "Danger: High Voltage!", which will be a far stronger deterrent to most people than a fence. Deterrence is what we are discussing here. Six, a locked fence, aside from being a maintenance and aesthetic nuisance, is in itself a safety hazard during an emergency. What happens when the brake should be pulled on the generator but can't because the gate is locked and nobody is home? Or the key can't be found? Seven, the utility may want access to the base of the tower to manually shut down the system in a power outage, in addition to using the safety disconnect. And, eight, grass is preferred to a fence in the event that a worker (or trespasser) should fall from the tower.

Other issues of safety include proper tower and footing design. Our tower is manufactured by Rohn, one of the largest tower makers in the country. It is specifically engineered for the Jacobs wind generator. It is also designed to withstand direct 100 mph winds. The footings are also designed by Rohn and must be made to their spec. The whole works is to be inspected by the building inspector. This is typical procedure for all manufactured towers.

High winds

Operation for our "Jake" peaks and remains constant in wind speeds over 25-27 mph. At wind speeds higher than 40 mph, each rotor blade automatically begins to twist on its axis, feathering itself out of the wind and so reducing speed, power, and torque. As wind speed climbs even higher, up around seventy-five miles per hour, the manual recommends shutting the system down using the manual brake. Wind generators of this



design have withstood hurricanes. All major wind generators today have some form of automatic governing system like this, with very, very secure track records. Wind generators are designed to survive without constant supervision at remote relay stations, where a breakdown causes severe problems.

How it works

The generator is in most cases a large ac alternator, which spins when wind turns the three rotor blades. In our case, each blade is eleven feet long. Together, the blades and hub have a diameter of 23 feet. For residential sized generators, this varies down to about eight feet and up to about twenty-six feet. As the wind machine spins, it generates electricity, the amount of power goes up and down depending on wind speed. This "wild" electricity is then run through a power conditioner, usually a synchronous inverter, which cleans up the signal and changes it into line quality electricity. Our inverter is hooked into the main breaker panel through a 60 Amp breaker. When the wind is blowing, we consume much of the power the wind generator is producing, reducing the power we draw off the utility grid. When we are not using all of it, the excess of generated electricity is pushed through a second meter (measures backflowing current) and back out to the utility's lines where the utility sells it to someone else. This wiring is governed by the National Electric Code, and is inspected by *both* the electrical inspector and the utility *before* hookup. We actually entered into a cogeneration contract with the utility.

Above: Our detent meters. Service meter on right measures inflowing power. Wind Generator meter on left measures outflowing power.

Birds

Several years ago, one wind farm in the Altamont Pass in California became known for bird kills—raptors, in particular, flying into the rotors or the lines coming from the generators, when strung above ground. This has raised the untrue criticism and unfounded concern that wind generators are especially dangerous to birds. Donald Aitkin, of the Union of Concerned Scientists, presented a study at MREF'93 (Amherst, Wisconsin) which shows that even in the Altamont Pass, the rate of kill is one bird per wind generator every 20 to 40 years, extremely low. The Minnesota Audubon Council of the National Audubon Society recently passed a resolution based on a report prepared by an independent consultant regarding the Buffalo Ridge area of Minnesota, and proposed commercial wind farms be sited in that area. The Council urged avian mortality

studies be done before siting of any large scale wind farm. However, the report went on to affirm that “avian mortality attributed to transmission lines, communications towers and other man-made structures was significantly greater than mortality reported to date for wind power installations.” It also revealed that “studies of single wind turbines during the 70’s and 80’s concluded that there was little to no impact on birds (Howell, et al, 1991).” In fact, birds are not stupid, and are statistically (and logically) far more likely to die hitting a high voltage power line, flying into a picture window or being hit by a car. Statistically, far more birds are killed by the environmental consequences of conventional power sources than by wind generators. For instance, Donald Aitkin points out that it would take the Altamont Pass wind farms about a thousand years to kill as many birds as the Exxon Valdez spill did in just two weeks.

ElectroMagnetic Interference (EMI)

EMI is another non-issue. The rotors of wind generators are typically made of basswood, sitka spruce, or fiberglass so they will bend and flex with wind gusts. Metal blades, found on large commercial wind generators, could cause an electromagnetic reflection. However, wood and fiberglass are electromagnetically transparent and cannot.

Noise

Our ordinance requires that we meet all standards set by the Pollution Control Agency regarding noise pollution. In fact, PCA workers I’ve talked to know this is not even an issue. Paul Gipe, in what is far and away the single most comprehensive resource manual on wind power, *Wind Power for Home and Business*, cites sound pressure levels in decibels for various noises. Wind in trees is rated at 55 decibels while our wind generator is rated at 50. Wind generators operate only in wind, when buildings and trees are making noise as well. While audible, the sound is neither loud nor obnoxious. One must compare this to other sounds we have come to regard as a necessary part of modern life: cars, airplanes, lawn mowers, etc., all far louder.

The barely-audible noise of a wind generator on a windy day is a small reminder of responsible and clean use of our natural resources. It takes burning about two pounds of coal to produce just one kiloWatt-hour of electricity. The average American house uses about 600 kiloWatt-hours a month—about 14,000 pounds of coal burnt every year. That’s a lot of acid rain. Most folks will opt for the whisper in the wind any day.

Aesthetics

The wind generator is generally painted a color to blend in with the sky. The common lattice type tower becomes invisible from a distance of a few thousand feet. The three blades of the rotor whipping around in the breeze is an intriguing and almost hypnotic sight to most people, like a campfire. It is less visually massive than a house or barn, since it is narrow and see-through. It is a colossal weather vane, reporting at a glance both wind speed and direction, drawing nearby residents into a more intimate relationship with the sky and its nuances of weather. But a wind generator’s purpose isn’t aesthetic; it’s utilitarian. It does a very important job: it produces pollution-free electricity so that natural beauty may be preserved. Those who still object must remember two truths. One, we do not own our view of others’ property. Two, far uglier than a wind tower is the specter of greenhouse gasses, coal smoke, acid rain, and mercury in our lakes. It’s easy to ignore if it’s not right next door, visible to the eye.

Above: Bolting the tower sections together.

A word about the utility

Most utilities these days are coming around to the idea of wind power, especially the rural electric cooperatives. Most utilities now have direct experience. Many rural and semi-rural cooperatives have at least one or two systems on line. At Anoka, Russ Wagner is the Energy Use Specialist. His job is to promote energy efficiency through a variety of programs. He also handles the cogeneration contracts. His help and support were extraordinary. Asking your utility if they have an energy use specialist is the best place to start. But do your homework up front. While utility approval for us was easy, *your* utility may be inexperienced with cogeneration and it could take *months*.

The Early Bird

One last word—don’t wait. Lobby your area to get a similar code on the books now, at the town, city, and/or

county level... don't let your "evil neighbors" get there ahead of you. And P.S.—it is all worth it, no matter the cost, watching those blades go around, knowing you are really being good to the earth. This is how things change—one conscious family at a time. Last night was windy up at Breezy. We shipped 135 kiloWatt-hours back to Anoka Electric. Just last week we got our first check from them, for $21.45. It was like winning the lottery. Some battles are still, after all, well fought.

The max system output we've recorded is 15.42 kW on a super windy day, although it's rated at 10 kW at 25 mph. The cost per Watt therefore is $.74 or $1.11, depending on rated or actual peak power production. I've excluded the cost of an analog anemometer from NRG systems at $125 since it *is* optional.

(Sample) Ordinance Regulating Wind Energy Conversion Systems (WECS)

Whereas this (Town, City, County) recognizes the inherent benefits of WECS to the environment and the township as a whole, and

Whereas (Town, etc.) is desirous of encouraging the positive use of wind power,

Now, therefore, the (Board) hereby ordains as follows:

Section 1. ADOPTION. Ordinance No_____ is hereby adopted and known as Wind Energy Conversion Systems (WECS).

Section 2. PURPOSE. The purpose of this ordinance is to establish standards and procedures by which the installation and operation of WECS shall be governed within the (Town, etc).

Section 3. APPLICATION. WECS may be allowed as a conditional use within any Zoning District, subject to the regulations and requirements of this ordinance, provided the property upon which the system is located is to be at least one acre in size.

Section 4. DECLARATION OF CONDITIONS. The Planning Commission may recommend and the (Board) may impose such conditions on the granting of a WECS conditional use permit as may be necessary to carry out the purpose of this ordinance.

Section 5. SITE PLAN DRAWING. All applications for a WECS conditional use permit shall be accompanied by a detailed site plan drawn to scale and dimension, showing the following:

A. Lot lines and dimensions.

B. Location and height of all buildings, structures, above ground utilities, and trees on the lot, including the proposed WECS and guy wires and anchors, if any.

C. Existing and proposed setbacks of all structures on the lot.

Section 6. CODE COMPLIANCE. Standard drawings of the structural components of the WECS and tower system, including base and footings, shall be provided along with engineering data and calculations demonstrating compliance with applicable provisions of the State Building Code. Drawings shall be certified by a Registered Structural Engineer. WECS electrical equipment and connections shall be designed and installed in compliance with the National Electrical Code. Building and Electrical permits shall be taken out by the applicant before construction.

Section 7. DESIGN STANDARDS.

A. Height. The maximum permitted height shall be 135 feet. In determining the height of a WECS, total system height shall be used as measured from the tower base to the highest extended rotor tip. 1. A Ratio of 1 foot to 1 foot setback shall be maintained between the system height and the nearest property line ("fall zone"). 2. The tower must meet all FAA regulations.

B. Setbacks. No part of a WECS, including guy wires or anchors, shall be located within a required front, side, or rear yard setback. WECS shall not be located within 30 feet of an above ground utility line, except the service drop for the property in question.

C. Rotor Size. Rotor diameters shall not exceed 26 feet.

D. Rotor Safety. The WECS shall be equipped with both an automatic and a manual braking device capable of slowing or stopping WECS operation in high winds and during maintenance.

E. Tower Access. To prevent unauthorized climbing, WECS towers must have all rungs removed within 12 feet of the ground.

F. Signs. WECS shall have 1 sign not to exceed 2 square feet, stating "Danger - High Voltage".

G. Electromagnetic Interference. WECS shall be designed and constructed so as not to cause radio and television interference.

H. Noise Emissions. Noise emanating from the WECS shall be in compliance with the State Pollution Control Standards.

I. Utility Interconnection. No WECS shall be interconnected with an electrical utility without the utility's prior knowledge and consent and a written agreement with the utility.

Section 8. INSPECTION. The (Town, City, County) hereby reserves the right to annual inspection of the WECS. If a WECS is not maintained in a safe and operable condition, the owner shall take expeditious action to correct the situation.

Section 9. ABANDONMENT. Any WECS not operational for a period of 6 consecutive months may be cited for repairs. If repairs are not made within a further 180 days, the WECS shall be deemed abandoned and shall be dismantled and removed at the expense of the property owner.

Section 10. INSURANCE. The WECS owner shall carry in full force and effect property liability (homeowner's policy listing the wind generator as an appurtenant structure) insurance in the amount of $500,000, and shall upon request provide proof of same to the (Town, City, County).

Section 11. VIOLATION. Violation of any of the provisions of this ordinance or of the provisions of the conditional use permit it contemplates shall be cause for revocation of the conditional use permit.

Section 12. EFFECT. This ordinance shall be in full force and effect from after its publication as required by law.

Editor's Note: I would not recommend that others offer the use of this ordinance, as it is written, as a model for their situations. The ordinance, written specifically for Shawn Otto's installation, is by far the most restrictive and burdensome that I have ever run across. Certain items, like limiting the rotor diameter to 26 feet and requiring duplicative braking devices, are actually specific features of Shawn's particular wind generator. Other items, like the redundant approval by a structural engineer or limiting the maximum tower height to 135 feet, seem arbitrary and pointless. The requirement for $500,000 liability insurance applies a burden that not even the utility required. I am not quite sure why Shawn's county or township felt it necessary to be so overbearing, unless there was some major butt covering going on. Add to this two conditional use permits at $450 each! These are the types of requirements one might expect in a rapidly developing area or a subdivision with covenants where the obviously intended purpose is to keep certain structures from even being built. It is a credit to Shawn that he persisted with his local government agencies until he was successful. Mick Sagrillo

Shawn & Becky Otto's System Cost

Used Jacobs 10kW with tower	$8,000	72%
Footings	$983	9%
Wire	$485	4%
Township conditional use permit	$450	4%
County conditional use permit	$450	4%
Excavation	$250	2%
Crane service	$245	2%
Wiring sundries	$185	2%
PVC conduit	$63	1%
Total	$11,111	

Above: The all volunteer tower assembly crew enjoys lunch in the dining room.

Access

Author: Shawn Otto, 12697 N 177th Street, Marine on St. Croix, MN 55047 • 612-436-7767

Shawn Otto is a poet, writer and entrepreneur. He and his wife Becky own and operate Fresh Paint Inc, a commercial painting contractor, which they established 10 years ago. They also own several historic commercial properties which they have restored. Shawn is trying to demonstrate with Breezy that environmentally low impact homes don't have to be impractical, overly expensive, or unattractive.

Rebecca Otto resigned as President of Fresh Paint to acquire a Master of Education because she felt teaching was a calling she had to answer. She now teaches to her Life Science students at Highview Middle School a comprehensive unit on environmental science that includes renewable energy, recycling, conservation, and field trips to Breezy.

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PHOTOCOMM

full page bled top, bottom, right
8.25 wide
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four color on negative

This is page 15

Above: Our house is powered by micro hydroelectric and solar electricity.

The 10 Kinzel/Kingsley Rules for Surviving Micro Hydroelectric Power
(and what the ads and manuals don't tell you)

Terry Kinzel and Sue Ellen Kingsley

In the fall of 1991 we started to build a small, off-the-grid house. Living next to Lake Superior in Michigan's upper peninsula, we knew that a source of electricity to supplement our PV panels would be necessary to get us through our dark and cloudy winter. The tall towers required for wind turbines were quite daunting. A stream flows through our yard, but thinking it viable only out West where the heads were high, we didn't seriously consider hydro power initially.

Attending the Midwest Renewable Energy Fair prompted us to reconsider hydro power and take actual measurements. We consulted with Paul Cunningham of Energy Systems and Design. Now, while our PV panels are an idle piece of art during the long night of December, our hydroelectric turbine produces generous, reasonably reliable power. Now in our third year of hydro power, this satisfactory state has not come without glitches. What follows is a Murphy's Law catalogue of things that will go wrong for any ordinary person attempting to grapple with micro hydroelectric power.

Rule Number 1
Never underestimate your ability to cheat on your measurements.

We measured the flow of our stream using two methods (HP #8, page 17 and HP #15, page 17)

coming up with about 750 gpm in the driest month. Since this was so much more than we needed, an overestimate wouldn't have caused much of a problem. Measuring head was another story. We used a 50 foot garden hose, stretched out in the stream bed. After a flow through the hose was established, we would raise the downstream end. The distance from the stream surface to the hose end was then measured, giving an estimate of the head over that section of the stream. The process was repeated until the portion of the stream from the proposed intake to the turbine was measured. Errors are easy to come by. There is at least a 2 inch difference between where the flow just begins to stop and where it actually quits. Inertia tends to accentuate this error. The stream surface is usually rippled. Of course, we erred on the side of more apparent head. We were off two feet over the 400 feet of the stream bed. We thought we had 17 feet of head when the reality was 15 foot of head.

This error was compounded by minimizing the height above the stream bed that the turbine must be placed so as not to be endangered by fluctuating water levels — allowing us to pretend we had a foot of head more than we actually did.

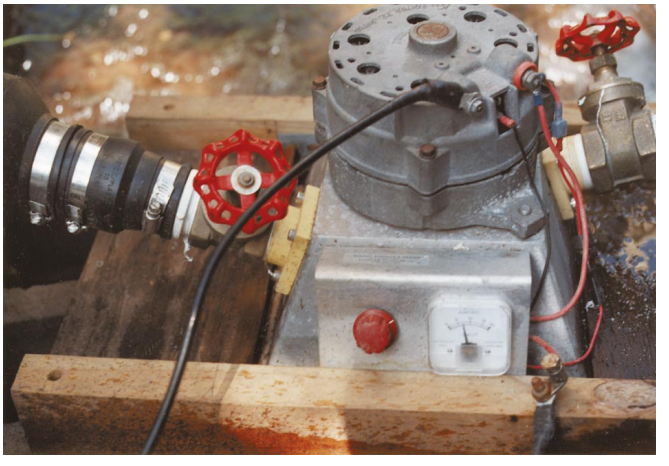
Rule Number 2
Never underestimate the ability of the technical elite to dazzle and befuddle us technological dummies.

Rule Number 2A
Never underestimate the ability of the technical elite to overestimate the knowledge of us technical dummies or to take for granted critical issues which seem obvious to them because they work with them daily, but are anything but obvious to us.

Having decided that our site had potential, we called Paul Cunningham at Energy Systems and Design, who after hearing of our site said something to the effect, "Whoa, you'll have so much electricity that it will be too cheap to meter." (Reminding me of the infamous promise of atomic power.) He subsequently launched into about 500 calculations in the next few moments, occasionally asking a question in some language faintly reminiscent of English. Having only the vaguest idea of the meaning of the questions and not wanting to appear too foolish, we gave answers we hoped would please him. The upshot: a shiny new turbine with the cutest little runner (water wheel) appeared in our garage a few weeks later.

Rule Number 3
Never underestimate friction.

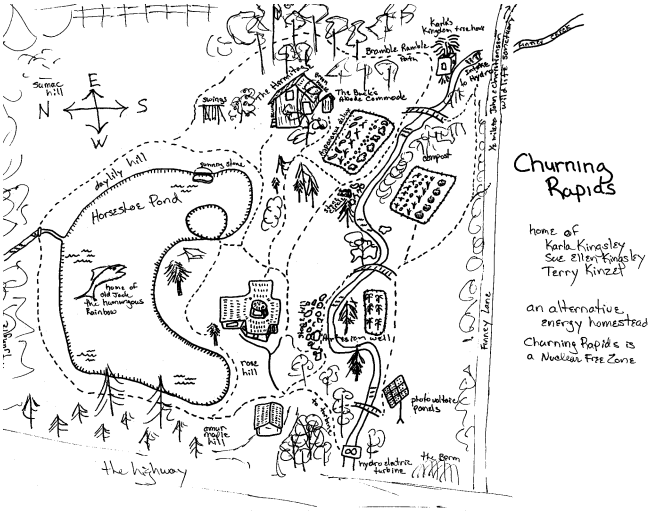
Our site (using our somewhat inflated values for head) called for a FAT (Ford Alternator Turbine). The turbine



Top: The intake impoundment and spillway. Water is filtered for debris and fed into two 4 inch diameter pipes.

Center: The ES&D microhydro turbine is fed with two 1 inch diameter nozzles.

Bottom: A close-up view of the turbine.



used two 3/4 inch diameter nozzles, delivering 75 gpm and yielding a predicted output of 90 Watts. Given the projected run of 300 feet (underestimated from the actual 350 feet — see Rule #1), 17 foot head, and 75 gpm flow, a 4 inch drain pipe was chosen to deliver the water. This was split just before the turbine and stepped down to two 1.5 inch pipes attached to the two nozzles. The turbine was bolted to a cement block sitting about two feet above the stream with a 6 inch stove pipe running through it to handle the water egressing from the turbine. Since there was only a single 4 inch pipe delivering water, it seemed obvious that a 6 inch pipe for the tail water would be sufficient. After some minor missteps, the water was hooked up and the wires connected in approximately the correct order. We let her rip, anticipating the glorious vision of the ammeter plunging off the scale as power surged through our circuits.

In fact, it was hard to tell that the analog ammeter in the turbine moved at all. However, using a digital ammeter and voltmeter, it appeared that the turbine was producing 1.2 Amperes at 13.0 Volts or a dazzling 15.6 Watts. Despair! Grief! Frantic calls! "Describe your set-up again." "What about egress?" "You need absolutely free egress so that friction won't slow down the wheel!" (See Rule #2A.) So we modified the system to lower the turbine to about one foot above the stream and gave it free egress, bringing the output up to 45 Watts. The turbine proved very reliable, causing no problems throughout the winter. The below predicted output was not a problem since there was still construction going on and we were still partly connected to the electric utility grid.

Rule Number 4

Never underestimate the capacity of technical dummies to learn and be helped by considerate, one-on-one, face-to-face consultation.

The next summer, we returned to the Midwest Renewable Energy Fair, after having a year of generally positive experience with our turbine. We were still vaguely unhappy that it was producing only about half the predicted power. After a delightful consultation with Don Harris, we made the following modifications:

1. Increased the nozzle size to two 1 inch nozzles (included with the original order).
2. Laid a second 4 inch pipe to decrease friction loss in the pipe, especially with the increased flow through the larger nozzles (see Rule #3).
3. Replaced a section of line that had been squished a bit by a gravel truck driving over it (see Rule #3).
4. Lowered the turbine to 6 inches above the stream bed.
5. Raised the dam at the intake site about 8 inches. A board across the stream creates a pool deep enough to cover the screened intake.

The result: 115 Watts of continuous power (2.75 kiloWatt-hours daily) for the past 18 months (with a few dramatic interruptions).

Rule Number 5

Never underestimate the power of water to wreak havoc.

A 4 inch pipe under only 7 or 8 pounds of water pressure doesn't sound very threatening. However, when a joint pops free at the last fitting before the turbine with you being the only object between an ocean of pressurized ice water and an expensive piece of electrical equipment, the experience is distressing.

Our intake is screened by hardware cloth and window screen in a wood frame into which the two 4 inch pipes fit. During most of the year, it requires no attention. However, during the spring melt and the fall leaf season, it periodically needs to be cleaned. A grass rake handles this task. However, during the times the screen is occluded with leaves, the columns of water in the pipes create a huge suction. On more than one occasion, the suction has collapsed the box or sucked the screen into the pipe. Always build this part of the system stronger than you ever dreamed necessary. (See Rule 2A.)

It rains, the stream surges, and the dam you thought was stronger than Grand Cooley washes out — a scenario guaranteed at least once. Although inconvenient, this allows opportunity to fulfill every little boy's dream of playing in streams.

A corollary here is: Don't Get Greedy. After coming to fully appreciate the importance of head and pressure, we tried to squeeze the most power possible out of the

Above: Karla, Terry, and Sue Ellen.

Top Right: Our Independence Day party with watermelon relay in progress.

Bottom Right: Churning Rapids during the winter.

turbine. We moved it as low above the stream as seemed safe. The same “once in a decade” fall storm that washed out the dam caused the stream to surge within millimeters of the turbine. Being away for the night (Rule #8), we only realized this later. Fortunately, during the winter, when we need the most power from the turbine, the stream is very steady. During the other seasons, the PVs produce so much power that the turbine can be raised safely out of harms way.

Rule Number 6
Never forget that even moving water freezes.

Water abhors discipline. The board we installed to raise the intake pool is buried in the stream bed. Water flows over the top of the board. Last winter, when the mercury hit -20°F, the top of the pool froze over, and the water chose to dig a channel underneath the board. The intake was left high and dry. We filled burlap bags with stones to span the breach and it held for the rest of the winter. No fingers or toes were lost to frost bite.

Having watched the stream for many winters, we knew it never got more than a crust of ice. Since most of the pipe was buried, we were not too worried by the prospect of freezing. The first winter, we lightly insulated the small portion that was exposed. Our actions were somewhat validated when we experienced no freezing problems. We went into the second winter with a modified system. With two 4 inch supply pipes, the water flowed more slowly. Also, the turbine nozzles are on opposite sides. So, one pipe is a straight shot while the other is forced to make a 180 degree loop to reach the back side, slowing the water further and exposing more pipe to subfreezing air. That winter was the coldest in many years. After our third night of 25 below, with highs reaching all of -15°F, we awoke to an output of about 50 Watts. Sections of the long and winding pipe were frozen. We were resigned to the idea that the entire pipe would now freeze solid and wouldn’t thaw ‘till summer. The next two days were above zero and for reasons that remain completely obscure to us, the pipe thawed. We beefed up the insulation in exposed portions and maintained full power for the remainder of the winter.

As a consequence of this experience, we modified the pipes last summer. Both delivery pipes each made a 90 degree turn and were stepped down from 4 inches to 2 inches in diameter before the bends. We reasoned that the water would be moving faster through the 2 inch pipes and would be less likely to freeze. Unfortunately, this resulted in a 15 watt loss of power (see Rule #3). Consequently we went back to the original design and put a bit more insulation on when the snow began to fly.

Rule Number 7
Never forget that, for most of us, electricity moves in mysterious ways.

The first year, after we got the output up to 45 Watts, we were troubled by the fact that the voltage at the turbine always read about 13.5 to 14.0 Volts. This did not seem high enough since our PV panels were producing 17.8 volts and we were using NiCd batteries (since replaced with lead-acid) with a fairly high voltage. Although we had plenty of power (our 120 vac circuits were still grid-connected at that time), we weren't quite sure where the electricity was moving. The low voltage was suspect in the below-predicted output. This was before we really believed Rule #3. Several calls to New Brunswick regarding this matter enriched Bell Telephone and re-confirmed Rules #2 and #2A. We returned the turbine. Paul stated that it worked fine and he couldn't understand why we were upset about the voltage. He managed a rapid turn-around time, paid for return postage, and installed a new, more efficient runner—all at no charge. Eventually, we came to realize that the open circuit/no load will be quite high, while the *working* voltage will always remain about 0.5 Volts higher than that of the battery bank. The electricity always flows in the correct direction. Why this is so remains a mystery to us. By the way, why is the sky blue?

Rule Number 8
Never will your hydroelectric system need attention when it is convenient.

This hardly needs elaboration, but be especially vigilant around the times you have purchased expensive, nonrefundable airline tickets — The System Knows.

Rule Number 9
Never will any local contractors, local electricians, or your friends know enough about your system to easily solve a problem.

In dealing with a problem, a mechanically-oriented and long-standing friend is your best bet. A corollary to this rule is: tell a house-sitter how to read the meters and how to shut the system off when there's trouble.

Rule Number 10
Never is the power output of your hydroelectric system affected by the phase of the moon or your menstrual cycle.

Check the output at least daily; it will be monotonously steady. If the power has fallen off even a few Watts,

Churning Rapids Fact Sheet
Property: 2.7 acres
House size: approximately 750 square feet
Builder: primary, Brian Maynard; secondary Dan DePuydt and Dave Bach
Design: Terry Kinzel
Energy Production
Photovoltaics: 8 Solarex MX60 PV modules mounted on a Wattsun tracker producing 480 Watts (28 Amps at 17.4 volts in full sun)
Hydroelectric: Energy Systems and Design; Ford Alternator Turbine with 16 feet of head, flow of about 75 gpm producing 115 Watts (9.4 Amps at 12.2 volts, continuous)
Energy Storage: Six L16 lead-acid industrial batteries in series and parallel to give about 1050 Amp-hours at 12 volts
Energy Management: Enermaxer charge controller with two 15 Amp hot water resistance coils to preheat water — in summer providing a substantial portion of our hot water
Inverter: Trace 2012 (has trouble with the clothes washer —inquire for details)
Metering: Cruising Equipment Amp-hour Meter, two SCI Mark III meters measuring battery voltage, Amps in from PV, Amps in from hydro, Amps out through DC junction box and Amps out through inverter
Heat Source: Reliance high efficiency wood stove with Olympic catalytic propane heater back-up
Hot Water: Enermaxer preheat, Aquastar instantaneous propane heater
Well: 362 foot artesian well; Flowlight booster pump to pressurize the system
Appliances: Sun Frost 12 cubic foot refrigerator, Sun Frost 10 cubic foot freezer, Caloric propane range and oven, Kenmore front loading washer
Lights: Electronic ballast compact fluorescents, and 12 volt halogen incandescents
The house is a modified superinsulated design (not completely air-tight and too much window area for maximum efficiency). All glazing is high performance —mostly Anderson windows
There is too much plumbing, partly due to the two-part development of Churning Rapids. The showers use low flow heads. The toilets are Kohler 1 gallon flush connected to a standard septic system and drain field. The Buck's Adobe Commode Composting Outhouse near the garden gets much use.
Other Features: The Hermitage is a guest house/retreat which is tucked into the rafters atop the greenhouse and sauna with dressing room. Pond, veggie gardens, flower gardens, bitsy woods, and rambling paths.

don't look to the moon or consult your calender looking for the reason. Rather, prepare to get wet.

Conclusion

This has been a summary of our experience with our micro hydroelectric turbine. Since we tried to describe some of the pitfalls that may be experienced by people of ordinary skills, it may seem that we are negative. This is not the case. While microhydro is not as simple (for the end user) as plugging into the grid, we have, with help, been able to solve each problem. With a modicum of maintenance and trouble shooting, microhydro has provided us with a generous supply of electricity and allows us to live very comfortably disconnected from the grid. Our batteries have it easy. They are never deep cycled. While most of the technical people we've dealt with suffer from the truths of Rules #2 and #2A, the equipment and service we received from Paul Cunningham were excellent. The advice from Don Harris at the Energy Fair proved invaluable. We would not hesitate to work with either of them in the future.

Access

Terry Kinzel and Sue Ellen Kingsley, RR1 Box 68, Hancock, MI 49930

ANANDA POWER TECH
black and white
3.5 wide
9.2 high

SIEMENS

full page bled

four color on negatives

This is page 23

Above: The interior of Jon Haeme's solar-power workshop. Note the battery box in the rear.

Portable Solar-Powered Workshop

Jon Haeme

A portable solar-powered workshop is a dream come true for me. It started back in the late '70s when I began collecting tools. I was inspired by the writings of J. Baldwin and Stewart Brand and began collecting appropriate tools to build the future. Over the years, my tool collection has outgrown my storage capacity. I run a one-man home improvement business, so a mobile workshop looked like a good idea.

In the fall of 1990, I bought a 20 foot enclosed cargo trailer and set up my shop in it. This allows me to take my whole shop to a work site and keep everything organized and protected. The following summer I was working at the home of Bill Becker, a teacher of design at the University of Illinois-Chicago. Bill turned me on to the idea of putting solar power to work on my trailer. It sounded good, but I didn't know much about it. He loaned me an old Real Goods Sourcebook in which I found out about *Home Power.* I subscribed right away. I soon was hooked on solar.

Getting Started

Bill put me in touch with Rick Lewandowski of Sunwize Energy Systems. I started out by purchasing two Solarex 60 Watt unframed laminates. Then upon learning of my home improvement skills, Rick

suggested a trade. He needed home repairs and I wanted solar panels. My luck continued as I learned that my friend, Tim Wilhelm (Wilhelm Engineering) had become a dealer for Sunwize. Tim does business out of Stelle, Illinois, which is just a few miles away from my farmhouse. Tim has given me good advice as well as good deals on system components.

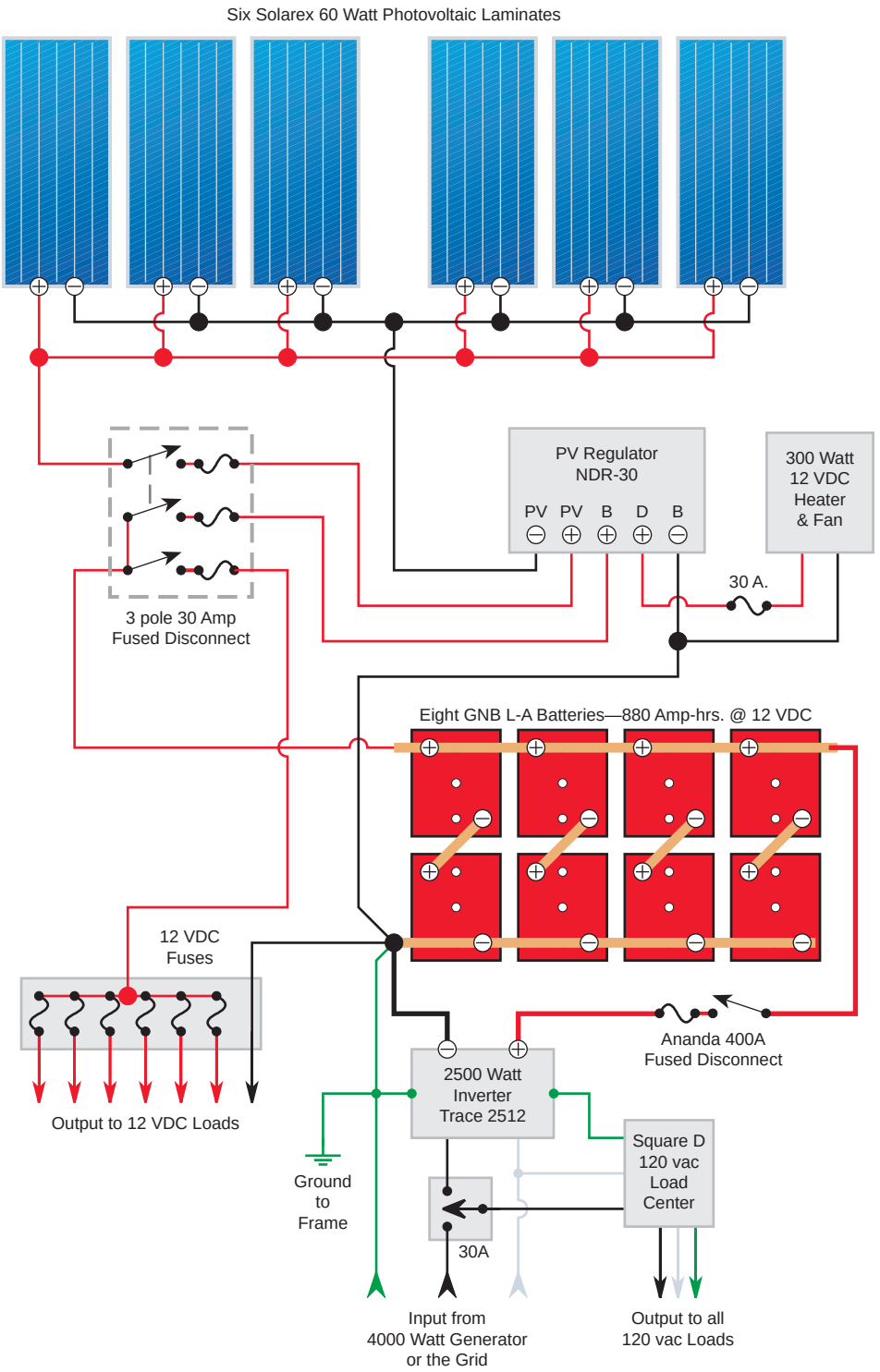
Nuts & Bolts

The system consists of six 60 Watt Solarex laminates framed in aluminum extrusion bought from the local salvage yard. With these, I built two panels of three laminates each, sealing the edges with silicone. I mounted the two panels on separate rotating aluminum frames. The frames are constructed of 2 inch x 2 inch x 3/16 inch aluminum angle from the salvage yard. The panels are connected to the frame with aluminum piano hinges. The panels are tilted up for winter use or laid flat for transportation. Each frame rotates on 12 inch turntable bearings from American Science and Surplus. I park the trailer at any angle convenient for the job site, and then adjust the panels for the most sun. I use 3/16 inch steel cable with turnbuckles and eyebolts to hold everything down to the trailer. I started out with zinc-plated hardware. Rusty bolts are a problem to work with and ugly as well, so stainless steel bolts are worth the extra cost.

Above: The exterior of the portable solar-powered workshop with PV laminates raised and ready. The laminates are securely mounted and can be stowed for travel.

Below: This view of the interior faces the rear door. Solar energy powers a radial arm saw, 14 inch metal cut-off saw, drill press, grinder, and a 2 horsepower air compressor.

Jon's PV-powered Portable Workshop



Charge Control

The array puts out 21 amps of current at 12 VDC in full sun. This is fed to the batteries through a pair of 6-gauge wires and a salvaged, 3-pole fused disconnect with 30 Amp RK-5 fuses. I use a Sunselector NDR-30 charge controller with temperature compensation and a charge divert circuit. When the batteries are full, I use the extra power to run a 300 Watt 12 VDC heater or fan. It's not much heat but nothing goes to waste.

Batteries

The battery consists of eight 6-volt golf cart batteries wired into a 12 VDC pack of 880 Amp-hours. They are connected with copper buss bar and enclosed in a large, pickup-style, plastic tool box. The box is vented to the outside through one-inch PVC pipe. A workshop is no place for exposed batteries. Enclose them to prevent shorts from dropped tools or sparks from the grinder igniting any hydrogen gas that's present.

12 VDC

I use the 12 VDC power directly for lights, radio, fans, tv and a thermo-electric cooler (Koolmate).

Inverter

For 120 vac power, I use a Trace 2512 inverter with 4/0 welding cable and a 400 Amp Ananda fused disconnect. The trailer is wired for power from the grid or a generator. I use a 30 Amp auto transfer switch (Todd Engineering) to keep the sources separate.

The Trace inverter will start and run any tool in my shop including a radial arm saw, 14 inch metal cut-off saw, drill press, grinder, and a 2 horsepower air compressor!

Mistakes

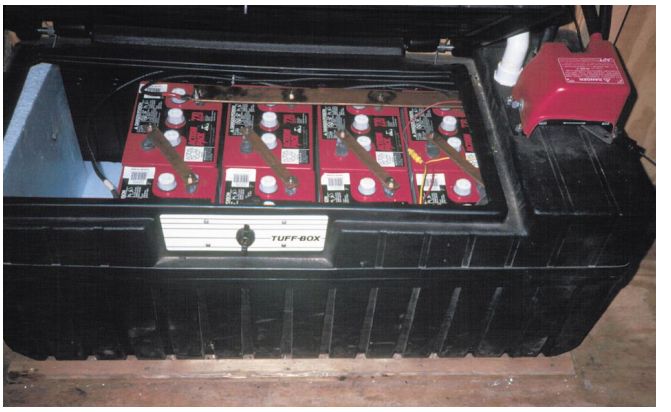
I had started out with one panel mounted and the other leaning against the wall in the shop, and I regret storing the panel unprotected. While drilling one day, a broken drill bit sailed across the shop and shattered one of the laminates. I was really upset. My friend Tim showed me an article on PV Panel Glass Repair (HP #21, page 12). Following the instructions, I now get 2 Amps from a laminate initially rated at 3.5 Amps. My experience with broken panels is to keep them dry and prevent further shattering. Cracks are worth the effort to repair, but badly shattered panels are not. Always test voltage and current before and after repair.

Other Uses

I use the trailer's system for power in my house when I don't have it on a job site. During the summer, it will run the well pump (110 vac 1/2 horsepower jack pump), a 120 vac RF-16 Sun Frost refrigerator and a light. In the winter, I just run the well pump. In an emergency, it could be used for backup power wherever needed.

Above: A view of the PV laminates from behind, showing their mounting structures.

Below: A pick-up tool box is used as a sealed, vented, battery box. Note the 400 Ampere fused disconnect for the inverter on the right.



Solar-powered Workshop Costs

#	Item	Cost	%
6	60 W Solarex PV laminates	$1,320	34%
1	2512 Trace inverter	$1,200	31%
	wire, conduit, copper buss, etc.	$350	9%
8	GNB golf cart batteries	$320	8%
1	Ananda 400 amp disconnect	$300	8%
1	NDR-30 charge controller	$133	3%
	scrap aluminum angle extrusion	$85	2%
1	Todd 30 amp transfer switch	$68	2%
1	plastic tool box (battery box)	$50	1%
1	Equus voltmeter	$40	1%
1	Todd 12 volt fuse box	$38	1%
	Total	$3,904	

The system seems to keep up with my present consumption level. Power tools take large surges when starting, but only run a short time. Most of my work is during the day in good weather. I recently received a 75 Amp Todd charger (a Christmas present from my wife, June) which I will use with a 4000 watt gas generator as a backup for this system. I rarely run low on power. Usually I just cut back consumption if the battery voltage gets low.

Future upgrades will include an amp hour meter. At present, I use an Equus voltmeter and a Radio Shack true RMS digital multimeter to monitor the system.

Keep On Dreaming

Now that I've built one dream, I can use it to build the next one. June and I have started building a straw bale house on our five acre mini-farm and hope to power it with solar and perhaps wind.

Access

Jon Haeme, RR1 Box 40, Herscher, IL 60941 • 815-426-2181

Wilhelm Engineering, 148 Sun Street, Stelle, IL 60919

American Science & Surplus, 3605 Howard Street, Skokie, IL 60076

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Understanding the Lead-Acid Cell

Richard Perez and Conrad Heins

All batteries are chemical engines. An understanding of the electro-chemical reactions taking place within the lead-acid cell will help you to use your battery more efficiently. An understanding of sulfation, which kills over 80% of all lead-acid cells, will help you make your battery last longer. The processes are simple and understandable to anyone who managed to stay awake during high school chemistry or physics.

Chemical Composition of Lead-acid Cells

The positive plates (anodes) within the lead-acid cell are made of lead dioxide (PbO_2). The negative plates (cathodes) are constructed of lead (Pb). The electrolyte is a dilute solution (≈25%) of sulfuric acid (H_2SO_4) and water. In the charged state, the electrolyte exists as ions, charged molecules. This is because sulfuric acid, when it dissolves in water, dissociates to form two hydrogen ions ($2H^+$) and a sulfate ion ($SO_4^=$). Both electrodes of the cell are completely immersed in this electrolyte. The reversible chemical reaction between the plates and the electrolyte allows the storage and retrieval of energy from the cell.

Lead-acid cells differ from most electrochemical cells because the electrolyte actually participates in the chemical reaction, plating out on the electrodes. In alkaline cells (nickel-cadmium and nickel iron), the electrolyte changes chemical compostion during charge and discharge of the cell. In a lead-acid cell the concentration of sulfuric acid in the electrolyte gradually decreases as the cell is discharged. If the cell is fully charged, then the electrolyte is rich in sulfuric acid. If the cell is fully discharged, then the electrolyte is depleted of sulfate ions and contains mostly water. This change in electrolyte chemical composition allows a rough measurement of the cell's state of charge with a hydrometer.

The voltage produced across a single lead-acid cell is a function of the electrochemical reaction between the active materials in the cell. All lead-sulfuric acid reactions proceed at about 2 Volts. This is a given factor. If more voltage is needed, then more cells must be added in series. The physical size of the cell is variable and determines the amount of current, at 2 Volts, available from the cell. In other words, the more massive the cell, the greater its capacity in Ampere-hours. No matter how large the single cell is, its voltage still will be around 2 Volts.

Discharge Reactions

When a lead-acid cell is being discharged, the active materials of both electrodes are changed into lead sulfate ($PbSO_4$). The sulfuric acid is gradually consumed from the electrolyte. The discharge chemical equations for the anode and cathode follow:

Discharge

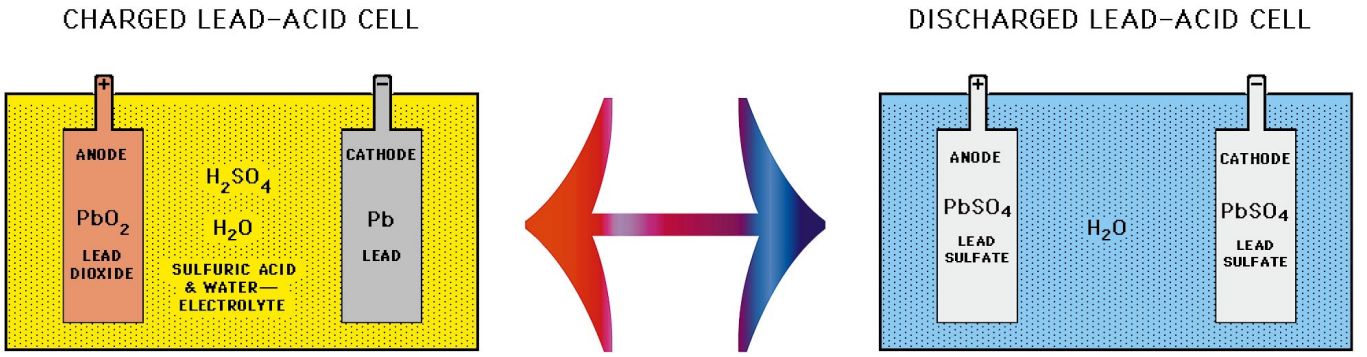
Anode: $PbO_2 + 4H^+ + SO_4^= + 2e^- \rightarrow PbSO_4 + 2H_2O$

Cathode: $Pb + SO_4^= - 2e^- \rightarrow PbSO_4$

As the cell is discharged, all the electrodes gradually become plated with lead sulfate ($PbSO_4$). $PbSO_4$ is an electrical insulator; it will not conduct current. The $SO_4^=$ (sulfate) ions are gradually consumed from the electrolyte and are bonded to the plates to form $PbSO_4$ (lead sulfate). This reaction releases two electrons at the cathode for every $SO_4^=$ radical which is bonded to the plates. This release of free electrons at the cathode is the source of the cell's electric power.

During discharge, the area of the plates available for reaction decreases as the surface of the plates becomes covered with the insulative lead sulfate crystals. This decrease in the active area results in a rise of the cell's internal resistance and a drop in the cell's voltage. Eventually the plates have no more area available for chemical reaction and the sulfate ions are consumed from the electrolyte. It is not possible to remove any more energy from the cell. At this point the cell is said to be fully discharged.

Actually, the process of discharging is terminated before all of the sulfate ions are consumed from the electrolyte. The ratings of battery manufacturers are based on the actual usable energy, which is much lower than the calculated energy of the battery using the masses of the reactants as a basis. This is because only the exterior portion of the electrode is exposed to the electrolyte. Commercially available batteries are rated between 15% and 40% of their theoretical electrochemical capacity.



$$PbO_2 + Pb + 2H_2SO_4 \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$$

Charge Reactions

The charging process is the reverse of the discharging process. During the charging process, a current (flow of electrons) is forced through the cell in the opposite direction by the application of voltage across the cell's anode and cathode. The reversal of the electronic flow within the cell causes the chemical bond between the lead and the sulfate ions to be broken, and the sulfate ions are released into the electrolyte solution. The charge equations for the lead-acid cell are as follows:

Charge

Anode: $PbSO_4 + 2H_20 - 2e^- \rightarrow PbO_2 + 4H^+ + SO_4^=$

Cathode: $PbSO_4 + 2e^- \rightarrow Pb + SO_4^=$

When all the sulfate ions have been removed from the plates and are in solution with the electrolyte, the cell is said to be charged. In actual practice, all of the ions cannot really be removed from the plates. Some continue to remain bonded to the plates in the form of lead sulfate. The inability of the charging process to remove all the sulfate ions bonded to the plates is one cause of the cell's finite lifetime. In time, the plate area available for reaction becomes smaller and smaller as more and more sulfate ions cannot be kicked free of the plates. Such a cell is said to be "sulfated" and suffers from "sulfation."

Sulfation

The longer the sulfate ions stay bonded to the lead plates, the more difficult they are to dislodge with the normal recharging process. The equalizing charge insures that the inevitable process of sulfation is delayed as long as possible. An equalization charge is a controlled overcharge of an already fully recharged cell. The usual equalization charge rate is C/20 (the capacity of the cell in Ampere-hours divided by 20 yields the equalization charge rate in Amperes).

The active material of both electrodes is a highly porous, three-dimensional structure that has a very large surface area. When the cell is discharged, a layer of microcrystalline lead sulfate coats the surface of the electrodes. Normally, this layer is so thin (only a few molecules thick) that it does not seriously increase the electrical resistance of the cell. The highly porous electrodes still have a very large surface area. However, things don't stay this way. Although lead sulfate is "insoluble", it dissolves in water to a very small extent. An equilibrium exists between precipitate and dissolved material, so that a small amount of lead sulfate is continually dissolving and an equal amount recrystallizing. The recrystallizing process results in crystal growth, with microcrystals merging together to form larger crystals with a smaller total surface area. The result is an electrode surface with a higher electrical resistance, a lower power density (resulting in more rapid voltage changes during charge and discharge), and a lower energy storage capacity. It doesn't take a lot of recrystallizing to reduce the active area of the electrodes by half. Finally, there has been enough crystalline rearrangement that the original plate surface is clogged with sulfate crystals. The effective surface area of the electrodes has been reduced by a factor of 100 or even 1000. The cell's electrical resistance is now so high that it may take over 20 Volts to move even a small amount of current through a cell that once was recharged easily with 2.6 Volts.

The most common cause (over 80%) of lost storage capacity in lead-acid cells is sulfation caused by chronic undercharging. The longer a lead sulfate ion stays bonded to the electrode, the more likely it is to form larger crystals and deeply coat the electrodes. This is why it is so important to fully, regularly, and completely, recharge lead-acid cells.

Equalization Charges

If the loss in cell capacity is due to sulfation, then a repeated series of equalizing charges can break most of the sulfate bonds. If your lead-acid cells have lost capacity, then a regime of equalizing charges is the first

procedure to try. First, fully recharge the cell, and then continue to charge the cell at a C/20 rate for five to seven hours. During equalization charges, the cell voltage will become very high, about 2.7 VDC per cell. This overcharge contains the necessary power to break up the smaller lead sulfate crystals and return these sulfate ions into solution in the electrolyte. The larger sulfate crystals, however, cannot be broken up even by an equalizing charge.

EDTA Treatment

If a sulfate bond spends several months on the plates and forms large crystals, then the lead sulfate can be chemically stripped from the plates. This is a job for an organic acid called EDTA, a close chemical cousin of vinegar. EDTA stands for the compound "ethylenediamine tetraacetic" acid. In chemical techie terms, EDTA is a "chelating agent" (chela is a Greek word for claw) that works particularly well on metal ions with a double positive charge. That's what makes it so effective on lead sulfate crystals. EDTA will dissolve lead sulfate, but it won't dissolve the lead or lead peroxide that makes up the healthy portions of the electrodes. EDTA comes in several forms. Use the tetrasodium variety.

The EDTA procedure is simple. Use one tablespoon of the EDTA powder for each quart of electrolyte in the cell. Mix the EDTA with a small amount (an ounce or two) of distilled water and add it to the cell. Recharge the cell and give it an equalizing charge. Recharging the cell speeds up the EDTA's reaction with the lead sulfate and strips the large sulfate crystals from the surface of the cell's plates more rapidly. After this reaction takes place, these large crystals fall to the bottom of the cell as a precipitate. The reaction can take from several days to several weeks depending on temperature, recharge rate, and depth of sulfation. Once the large sulfate crystals are stripped from the plates, new lead is exposed and can enter into bonding with the sulfuric acid electrolyte.

The amount of EDTA specified here is a ballpark guess. If your cells are badly sulfated, then you may wish to repeat the EDTA treatment in a month or so. In severe cases of sulfation, more sulfuric acid may be added to the cell to replace lost sulfate ions in the electrolyte. Here, your hydrometer is your best guide. A specific gravity of 1.260 is standard for a fully charged cell. If after EDTA treatment, your specific gravity is below 1.200, then replace water lost from the electrolyte with new electrolyte (specific gravity 1.260) instead of distilled water. Feedback from hundreds of HP readers who have tried EDTA indicates that it will not harm the cells. For a complete discussion of EDTA treatment, see HP #20- pg. 36, and HP #21- pg. 36.

Hi-Tech Sulfate Solutions

I *(Richard)* am testing two new products which prevent and reverse sulfation in lead-acid cells. These devices are called "MiniPulse™" which runs on 12 or 24 VDC and "DuraPulse™" which is powered by 120 vac. These devices use pulses of electricity, timed to the resonant frequency of the sulfate bond, to break up large sulfate crystals. These pulse devices may well replace EDTA as the cure for sulfated cells. Their use on new batteries may prevent or delay sulfation. The sulfate ions liberated by the pulse method return into solution in the electrolyte, rather than dropping uselessly to the bottom of the cell. These devices are relatively inexpensive ($100 to $170) and may pay for themselves many times over by extending battery life. I am currently testing both models on some seriously sulfated lead-acid cells, so look for a report on our experiments in the near future.

Working with, rather than against, the lead-acid cell

Here is a short list of things that you can do to help your lead-acid cells live long and prosper:

1. Bring all the cells in the battery to a full state of charge weekly. This is really a matter of system design and energy management. Systems with undersized power sources will eventually have battery problems. Folks who consume more than they produce will eventually have battery problems.
2. Perform equalization charges every two months or every six deep cycles, whichever comes first.
3. Never replace lost water from the cells with anything other than distilled or de-ionized water. Well water and, sadly, even rainwater are not pure enough for the cells.
4. Keep your cells warm in the winter and cool in the summer. The lead-acid reaction works best and most efficiently between 60 and 80 degrees F. Operation above 110°F or below 40°F will decrease apparent battery capacity and shorten battery life.
5. Keep the tops of the cells clean and corrosion free. Cells are electrochemical machines which don't tolerate contaminants, so run a clean scene. While baking soda is excellent for cleaning corroded hardware, don't use baking soda on the tops of cells. If the acid schmaze can get out, then the baking soda can get in. Baking soda can neutralize the electrolyte within the cell and cause cell failure.

Access

Authors: Richard Perez, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179 voice/FAX.
Internet email: richard.perez@homepower.org

Dr. Conrad Heins, Cedar Valley Workshops, 3000 East Cedar Valley Road, Traverse City, MI 49684 • 616-228-7029.

EDTA Source: Trailhead Supply, 325 E. 1165 N., Orem, UT 84057 • 801-225-3931

“MiniPulse™”and “DuraPulse™” Source: Mainline Electric, 4324 Fern Valley Road, Medford, OR 97504 • 800-221-9302 • Voice/FAX 503-535-9862

STATPOWER
7.5 wide
5 high
black and white on negative

SOLOPOWER
7.4 wide
3.3 high
black and white
camera ready

Apples and Oranges: An Update

MIck Sagrillo

You're about to make the big decision: should a wind generator be in your future? You've analyzed your resources, both environmental and monetary, and weighed the pros and cons of having a wind generator. The only question left is, which system should you choose?

I can't answer that question for you. However, I can give you the tools to help you make that big decision. Those tools are the detailed information, specifications, and power curves for a number of wind systems.

(Author's note: This article was originally published in 1993. Since that time, four new wind generators have come on the market, as reflected in this version.)

Background

This article will review all of the commercially available wind systems that are sold in the United States by bona fide manufacturers. An explanation is in order.

In the late '70s and early '80s, the federal and state governments offered tax rebates and incentives to folks who bought renewable energy systems, including wind generators. The objective of the program was to help a fledgling RE industry get off the ground, while weaning the United States from foreign energy supplies by growing more of our own. While the intentions of the tax incentive program were good, the results for the wind industry were nearly devastating. (Similar results occurred with the other renewables, but this article will be restricted to wind electric systems.)

Scores of companies opened shop and began building wind electric equipment. Virtually all of these companies failed. Customers, however, were left with wind generators that didn't work, plus a bad taste in their mouths for RE.

The Vantage Point

Lake Michigan Wind & Sun, of which I am president, is in the business of rebuilding and making parts for dozens of different models of wind generators that were manufactured by now defunct companies. We do a lot of reverse engineering. That is, we try to identify system design flaws so we can correct them. By making the necessary upgrades, customers can turn a poorly designed wind generator into a usable piece of equipment.

Because of the services we perform, we have a unique perspective as to where the wind energy marketplace is. We are in business primarily because all but a handful of wind generator manufacturers failed to build reliable equipment. As we found out a decade ago, anyone can make a wind generator, but making one that will work for years is another matter entirely!

So when I say "bona fide manufacturers," I am not trying to slight anyone. I do, however, want to inform readers who the successful manufacturers are. As a dealer for all of the manufacturers represented in this article, we have extensive experience with every wind generator reviewed. While we sell all of the new wind systems available today, we have no particular allegiance to any one manufacturer. I have tried to fairly represent their products in relation to all others reviewed. They are the survivors, because they have learned how to manufacture reliable products that have withstood the test of time.

Addenda

Two more points before we start. First, this article does not include either the Survivor or Soma wind generators, both of which have received press in Home Power. Neither machine is commercially available in the United States at this time.

Second, a word on failures is in order. You may know someone who has or had one of the wind generators reviewed here that has suffered a failure of some sort, maybe even a catastrophic failure. Don't prejudge all wind generators based on a few isolated instances. Sure, there have been failures, even with the best of wind systems. Paul Gipe of the American Wind Energy Association reminds us to look only as far as the automotive industry for a comparison. The auto industry is a multi-billion dollar industry spanning over nine decades. Yet they still don't always get it right, as evidenced by the numerous annual recalls of their products.

What you should be interested in is trends, not the occasional failure. Problems with a wind generator usually occur early in the system's life. All wind generator manufacturers have experienced some failures, as have all other RE equipment manufacturers. Numerous reports of problems with a particular manufacturer should raise a red flag in your mind. However, as stated earlier, those systems have not been included in this article.

The Envelope, Please

The following table summarizes all of the various features that you should seriously consider when shopping for your wind system. Explanations for the column headings follow. All of the specs have been provided by the manufacturers.

Manufacturer and Model The various models are listed in ascending (i.e., increasing) output to help with comparisons. Manufacturers' (or their major distributor) addresses and phone numbers appear at the end of the article.

All of the wind generators presented are new equipment with the exception of the remanufactured Jacobs Wind Electric generators. Even though the old Jacobs has not been made for 40 years, it is still considered by many to be state-of-the-art technology. They have been "remanufactured" (that is, rebuilt with all new components and put back onto the streets with a warranty) by various companies for at least two decades. The Jacobs wind generator is the yardstick by which many judge today's wind equipment.

Rated Output, in general, refers to the maximum power output of the system. Any wind generator may peak at a higher power output than the rated output. The faster you spin a wind generator, the more it will produce, until it overproduces to the point that it burns out. Manufacturers rate their generators at a safe level well below the point of self-destruction.

Rated Wind Speed is the wind speed at which the wind generator reaches its rated output. You will notice that there is no standard rated wind speed, although most companies rate their systems somewhere around 25 to 28 mph. With regards to rated wind speed, note that not all wind generators are created equal, even if they have comparable rated outputs. In the past, some manufacturers have abused the concept of rated output by fudging on the rated wind speed. For example, a wind generator that reaches its rated power at 50 mph is obviously not the same animal as one which generates a comparable rated output at 25 mph. How often do you see 50 mph winds?

Rated rpm refers to the alternator or generator rpm at which rated output occurs. Generally, the smaller the rotor, the faster the blades spin. Rpm will have an effect on the amount of noise that the wind generator produces. We'll consider noise later.

Cut-in Wind Speed is the wind speed at which the wind generator begins producing power. For all practical purposes, there is no usable power in the wind below about 6 to 7 mph, even though the blades may be spinning. This holds true unless you greatly oversize the rotor to allow it to capture power in low wind speeds. But then you open up all sorts of worm cans when trying to control generator output at higher wind speeds.

While some manufacturers claim outputs at very low wind speeds (3 to 4 mph), from my point of view, a few watts does not constitute usable power. At best, this minimal output only overcomes the power losses caused by a long wire run or the voltage drop due to diodes.

Rotor Diameter is the "fuel collecting" part of the wind generator. The bigger the rotor diameter, the larger the collecting area or the swept area. While some manufacturers rate their products at different wattages or wind speeds, the output of a wind generator is primarily a function of its swept area.

Number of Blades refers to the number of blades in the rotor. This is primarily a design consideration for the manufacturer. The greater the number of blades, the more torque the rotor can produce. A certain amount of torque is necessary to get the rotor spinning from a stopped position. However, torque is inversely related to rotor conversion efficiency. When you are trying to generate electricity competitively with the power company, efficiency is of prime concern.

The fewer the number of blades in the rotor, the more efficient the rotor becomes. One blade is the ideal, but poses some dynamic balance problems. Two blade or three blade rotors are seen most often. The question arises, why use three blades if two blades are more efficient? Time for a digression!

"Yaw" is a term that refers to a wind generator pivoting on its bearings around the tower top to follow the continually changing direction of the wind. Two-bladed rotors pose a problem as the wind generator yaws. A two-bladed rotor actually sets up a "chatter" as it yaws, which causes a strain on all of the mechanical components.

Chattering occurs during yawing because of the continuous changing of the position of the blades in the plane of rotation. When the blades are in the vertical position (that is, in line with the tower) there is little resistance to the rotor yawing around the tower. However, when the blades rotate 90 degrees so that they are in the horizontal position (that is, at right angles to the tower, or parallel to the ground) they pose maximum resistance (or inertia) to any yawing motion. The result is a rhythmic starting and stopping of the yaw twice per revolution of the rotor. This starting and stopping of the yaw is what is called blade chatter. Three-bladed rotors eliminate the chattering problem

WIND GENERATOR

Model	Furlmatic 910	Air	Windseeker 502	Whisper 600
Manufacturer	Marlec Engineering	Southwest Windpower	Southwest Windpower	World Power Technologies
Rated Output in Watts	150	300	500–12V 575–24V	600
Rated Wind Speed	36 mph	28 mph	30 mph	25 mph
Rated rpm	900 rpm	2000 rpm	2000 rpm	1100 rpm
Cut-in Wind Speed	4 mph	5 to 7 mph	5 mph	7 mph
Rotor Diameter	3 feet	3.75 feet	5 feet	7 feet
Number of Blades	6	3	2 or 3	2 or 3
Blade Material	Glass reinforced nylon	Carbon Reinforced Thermo Plastic	Basswood	Basswood
Airfoil	True	True	True	True
Lateral Thrust	100 pounds	80 pounds	100 pounds	150 pounds
Governor System	Side-facing	Blade Stall	Tilt-up	Tilt-up
Governing Wind Speed	37 mph	35 mph	35 mph	27 mph
Shut-down Mechanism	none	Dynamic Brake	none	Dynamic Brake
Tower Top Weight	38 pounds	13 pounds	20 pounds	40 pounds
Marine Option Available?	No	Yes	Yes	Standard
Generator Type	PM Alternator	PM Alternator	PM Alternator	PM 3 phase Alternator
Tower Top cost	$820	$550	$875–$1075	$980–$1080
Dollars per Watt	$5.47	$1.83	$1.75–$2.15	$1.63–$1.80
Battery Systems	12V & 24V	12V & 24V	12V to 180V	12V to 240V
Utility Intertie Available?	No	No	No	No
Resistance Heating?	No	No	No	Yes
Water Pumping?	No	No	DC	AC
Est. Mo. KWH @ 10MPH	15 kWh (14%)	35 kWh (16%)	60 kWh (17%)	70 kWh (16%)
Est. Mo. KWH @ 12MPH	22 kWh (20%)	43 kWh (20%)	90 kWh (25%)	110 kWh (25%)
Warranty	1 year	3 years	1 year	2 years
Time in business	17 years	10 years	10 years	6 (17) years
Routine Maintenance	None Recommended	None Recommended	None Recommended	Visual Inspection
Notes		Built-In Regulator	Built-in Regulator	Includes Rectifier Box

COMPARISON TABLE






Wind Baron 750	BWC 850	Whisper 1000	BWC 1500	Jacobs Short Case	Jacobs Long Case
Wind Baron	Bergey Windpower	World Power Technologies	Bergey Windpower	Lake Michigan Wind & Sun	Lake Michigan Wind & Sun
750	850	1000	1500	1800–24V 2400–32V to 48V	2400–24V 3000-32V to 48V 400-200V UTI
30 mph	28 mph	25 mph	28 mph	18 mph	23.5 mph
1100 rpm	520 rpm	935 rpm	480 rpm	225 rpm	275 rpm
5 to 7 mph	8 mph	7 mph	8 mph	6 mph	6 mph
6.17 feet	8 feet	9 feet	10 feet	14 feet	14 feet
3	3	2 or 3	3	3	3
Basswood	Fiberglass	Basswood or Carbon Fiberglass	Fiberglass	Sitka Spruce	Sitka Spruce
True	Single-surface	True	Single-surface	True	True
	240 pounds	250 pounds	375 pounds	750 pounds	800 pounds
Tilt-up	Side-facing	Tilt-up	Side-facing	Blade-activated	Blade-activated
35 mph	35 mph	27 mph	30 mph	18 mph	23.5 mph
Dynamic Brake	None	Dynamic Brake	Folding Tail	Folding Tail	Folding Tail
38 pounds	86 pounds	55 pounds	168 pounds	450 pounds	550 pounds
Standard	Yes	Standard	Yes	Yes	Yes
PM 3 phase Alternator	PM 3 phase Alternator	PM 3 phase Alternator	PM 3 phase Alternator	DC Generator	DC Generator
$1,395	$1995–$2095	$1590–$2120	$4795–$5295	$5,500	$6,500
$1.86	$2.35–$2.47	$1.59–$2.12	$3.20–$3.53	$2.29–$3.06	$1.63–$2.71
12V to 48V	12V & 24V	12V to 240V	12V to 120V	12V to 120V	12V to 120V
No	No	Yes	No	Yes	Yes
No	No	Yes	Possible	Yes	Yes
DC	No	AC	AC	DC	DC
70 kWh (13%)	80 kWh (13%)	120 kWh (16%)	125 kWh (12%)	250 kWh (18%)	340 kWh (16%)
108 kWh (20%)	122 kWh (20%)	190 kWh (20%)	220 kWh (20%)	440 kWh (30%)	520 kWh (24%)
2 years	2 years	2 years	2 years	2 years	2 years
17 years	17 years	6 (17) years	17 years	14 years	14 years
Visual Inspection	Visual Inspection	Visual Inspection	Visual Inspection	Visual 2X & Grease	Visual 2X & Grease
Controls Included	Controls Included	Includes Rectifier Box	Includes Battery or Pump Controller		

Model	Whisper 3000	BWC Excel	Jacobs 23-10	Jacobs 29-20
Manufacturer	World Power Technologies	Bergey Windpower	Wind Turbine Industires	Wind Turbine Industires
Rated Output in Watts	3000	10,000	10,000	20,000
Rated Wind Speed	25 mph	27 mph	25 mph	25.5 mph
Rated rpm	625 rpm	350 rpm	200 rpm	175 rpm
Cut-in Wind Speed	7 mph	7 mph	8 mph	8 mph
Rotor Diameter	14.8 feet	23 feet	23 feet	29 feet
Number of Blades	2 or 3	3	3	3
Blade Material	Carbon Fiberglass	Fiberglass	Sitka Spruce	Sitka Spruce
Airfoil	True	Single-surface	True	True
Lateral Thrust	700 pounds	2000 pounds	1500 pounds	2500 pounds
Governor System	Tilt-up	Side-facing	Blade activated & Side-facing	Blade activated & Side-facing
Governing Wind Speed	27 mph	33 mph	25 mph	25.5 mph
Shut-down Mechanism	Dynamic Brake	Folding Tail	Mechanical Brake	Mechanical Brake
Tower Top Weight	130 pounds	1020 pounds	1400 pounds	2300 pounds
Marine Option Available?	Standard	Yes	Standard	Standard
Generator Type	PM 3 phase Alternator	PM 3 phase Alternator	Brushless 3 ph. Alternator	Brushless 3 ph. Alternator
Tower Top cost	$3880–$4260	$16,950–$19,475	$13,100	$16,500
Dollars per Watt	$1.30–$1.42	$1.69–$1.95	$1.31	$0.83
Battery Systems	12V to 240V	48V or 120V	120V	120V
Utility Intertie Available?	Yes	Yes	Yes	Yes
Resistance Heating?	Yes	Possible	Yes	No
Water Pumping?	AC	AC	AC	AC
Est. Mo. KWH @ 10MPH	320 kWh (15%)	925 kWh (13%)	850 kWh (12%)	1644 kWh (11%)
Est. Mo. KWH @ 12MPH	520 kWh (24%)	1425 kWh (20%)	1250 kWh (18%)	2691 kWh (18%)
Warranty	2 years	2 years	1 year	1 year
Time in business	6 (17) years	17 years	8 years	8 years
Routine Maintenance	Visual Inspection	Visual Inspection	Grease & Oil change	Grease & Oil change
Notes	Includes Rectifier Box	Battery Control or UTI Inverter	Gear box (not direct drive)	Gear box (not direct drive)

because there is never enough inertia from the one blade in the horizontal position to set up a blade chatter in the first place. The horizontal blade is more than counterbalanced by the other two blades working somewhere off on their own. Well-balanced three-bladed rotors operate very smoothly with no noticeable vibration or chatter.

World Power Technologies has come up with a unique solution to the two-blade problem on their Whisper wind generators. The blades are mounted on a spring plate. The spring plate flexes to absorb some of the yawing vibration and helps mitigate the yawing chatter on the 2-bladed Whisper wind generators.

It should be noted that several of the manufacturers offer two blade units as their standard model with a three blade option. Regardless of the number of blades on the wind generator, proper balancing is critical for a smooth running machine. Severe chattering or a poorly balanced rotor may result in the failure of either the wind generator or, in extreme cases, the tower.

Blade Material refers to what the blade is constructed of. Within the last decade, blade material has fallen into one of two categories: wood or extruded fiberglass. While more expensive for materials and labor, wood is still considered by many as the material of choice for blades. Blades do a lot of flexing. That's what trees did as a side job for most of their lives.

There is no question that sitka spruce is the "primo" material for wood blades. Sitka has one of the highest strength-to-weight ratios of any material ever used by blade makers, as well as airplane and boat builders. Done properly, however, extruded fiberglass also makes an excellent blade material. Bergey holds the secrets with extruded fiberglass. Two generators, the Rutland and the Air, use injection molded plastic for their blades.

Airfoil refers to the shape of the blade. Two types of airfoils are used by wind generator manufacturers: true airfoils and single-surface airfoils. The cross section of a true airfoil blade would look much like an airplane wing, that is, curved on one side and more or less flat on the opposite side. Single-surface airfoils have matching curves on both sides. They are easily formed by the extrusion process. The differences between the airfoils occur in three areas: performance, noise, and manufacturing cost. True airfoils are quieter and perform better than single-surface airfoils. But single-surface airfoils are cheaper to manufacture than the more complex true airfoils.

Lateral Thrust at the Tower Top is mainly a design consideration for tower manufacturers. Lateral thrust, the horizontal force vector, is a function of swept area of the rotor, the resistance the tower presents to the wind, and wind speed. The greater the lateral thrust, the stronger (and therefore, more expensive) the tower must be and the larger the concrete footings must be.

Governing System refers to the manner in which the wind generator protects itself from high winds and rotor overspeed situations. Governing is necessary for two reasons: to protect the generator itself from overproducing and burning out, and to protect the entire system from flying apart in high winds.

The governing devices used on all of these wind generators fall into three general categories: those that reduce the area of the rotor facing the wind, those that change the blade pitch, and those that stall the rotor.

Changing the swept area of the rotor is accomplished by either tilting the rotor up and out of the wind (Wind Baron 750, Windseeker, and the Whispers) or by side facing the rotor out of the wind by moving it around the tower (Rutland and Bergeys). In either case, the fixed-pitched rotor is offset either above or to the side of a pivot point. Wind pressure on the rotor causes it to pivot out of the wind. These governing mechanisms are almost a foolproof method of controlling rotor speed. However, they do come with a cost. Once the rotor governs by tilting up or side facing, it produces little power.

Blade-activated governors work by pitching the blades out of their ideal alignment to the wind. The greater the rotor speed, the greater the degree of pitch. Having more moving parts than either the tilt-up or side-facing mechanisms, they are considerably more complicated governing devices. However, they offer much better power curves, as we will see later. Any wind generator blade that spins fast enough will eventually "stall" aerodynamically and not spin any faster than this design speed. The tiny Air uses this phenomenon as a governing technique. The Air's fixed pitch rotor is stall regulated at the top end of its rpm range.

Governing Wind Speed is the wind velocity at which the governing mechanism is fully operational.

Shut-down Mechanism refers to the manner in which the rotor can be stopped and the generator shut down. This is desirable for maintenance or repairs, or whenever else you do not want the rotor to be turning.

A common shut-down method is to fold the tail (all of these systems have tails) so that it is parallel to the blades. This takes the rotor out of the wind, and it will cease to spin. Folding the tail involves either cranking or uncranking a cable which will furl or unfurl the tail, depending on the system. The cable winch is at the

base of the tower, meaning you must go out to the tower to accomplish the shutdown. Wind Turbine Industries uses the winch to activate a mechanical brake which slows the rotor to a stop on their 10 and 20 kW Jakes.

Dynamic braking is unique to permanent magnet alternators. Dynamic braking works as follows: if you short out the three phases of a permanent magnet alternator, it will overpower the ability of the rotor to spin the alternator (i.e., stall the blades) and the rotor will come to a stop. This can be done from the comfort of your home!

Tower Top Weight refers to everything that goes on top of the tower: generator, governor, rotor, tail, and turntable assembly. You'll notice that there is wide variation in tower top weights. Based on experience, I side with the "school of heavy metal," manufacturers who believe that beefiness of components is directly related to the longevity of equipment life.

Marine Option indicates whether the unit is suitable for use in a marine climate (within one mile of an ocean or on an island) or if this option is available for an additional price.

Generator Type describes the electrical generator that is used in the system. Three types are used: permanent magnet alternators, DC generators, and brushless alternators. A little about the pros and cons of each is in order. But first, another digression!

Electrical generators work by having a wire (or many wires) pass through a magnetic field. The movement of the wire through the magnetic field induces current to flow through the wire. It's the flowing current that we want for our batteries and grid intertie inverters.

Permanent magnet (PM) alternators use, as the name implies, permanent magnets for the field. PM alternators are lighter in weight than generators that use copper wire-wound fields. Alternators produce three-phase "wild" ac current. "Wild ac" means that the frequency is variable with the wind speed. As rotor speed increases, so does the frequency. Wild ac cannot be used by standard 60 cycle appliances, and must be rectified to DC before it can be used in either a battery bank or a utility tie-in synchronous inverter. DC generators simply produce DC current.

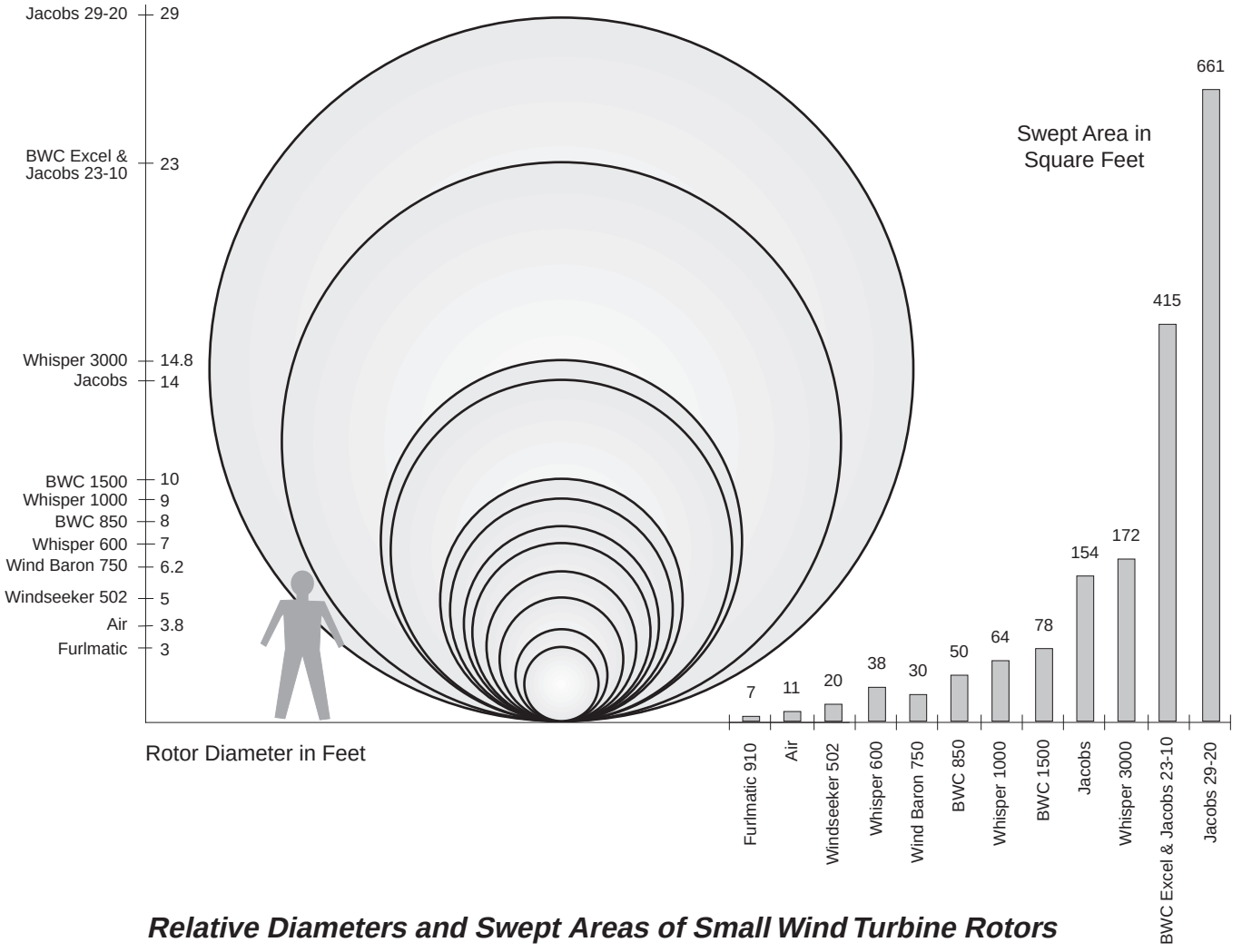
Some manufacturers claim that PM alternators are better in wind systems than DC generators, primarily because there is less maintenance involved with an alternator than with a generator. DC generators have brushes, which have to be replaced periodically, maybe every six to 10 years or so. PM alternators do not have brushes. From my perspective, replacing brushes once or twice a decade can hardly be construed as a maintenance problem.

The real advantage of permanent magnets to a manufacturer is that the permanent magnets are relatively cheap. Compared to the cost of the copper wire needed in a wound field, permanent magnets are a bargain! Cheaper materials means that a manufacturer can be more competitive in pricing the product. PM alternators offer two advantages to a system owner. First, you can take advantage of dynamic braking, described earlier. Second, three-phase ac current can be transmitted through wires more efficiently than DC current, meaning that you can keep your wire costs down.

However, PM alternators do have one disadvantage compared to generators with a wound field. Because the magnets in a PM alternator are permanent, the amount of magnetism they exude, or their flux density, is fixed at the magnet's maximum amount. The amount of flux density in a wire-wound field magnet, however, is proportional to the amount of current that it draws and, somewhat, to the amount of voltage present. (I'm going to simplify this greatly, so all you electrical engineers out there, please don't drop your teeth!) In other words, the higher the voltage present in a wire-wound field, the more current the field will draw, and therefore the stronger the magnet will be. As the rotor speeds up, the flux density of the field increases.

The nice thing about this arrangement is that the magnets in a wire-wound field generator put very little magnetic drag on the spinning armature when little wind is blowing. But there's plenty of magnetic drag available when the wind is cranking, and the generator is peaking. The power curve of a DC wire-wound field generator, then, nicely follows the power available in increasing wind speeds (the cube law). That's just the way it should be. PM alternators, on the other hand, always have maximum magnetic drag on the alternator's current generating stator. This means that performance is at its peak at really only one spot on the entire power curve. All other points on the power curve are a compromise, especially at the low wind speed end of the curve, the part of the curve where the wind system spends most of its life.

In order to overcome this problem, manufacturers using PM alternators have to design more torque into their blades just to get the rotor spinning in low winds. But remember, torque is inversely related to efficiency. So while PM alternators are simpler (no brushes) and cheaper to build than DC generators, the simplicity comes at a price. To be fair, DC generators are more expensive than PM alternators.



Relative Diameters and Swept Areas of Small Wind Turbine Rotors

Brushless alternators offer the best of both worlds. The fields are wire-wound rather than permanent magnet, but there are no brushes to replace. Their power curve is similar to a DC generator. On the down side, brushless alternators are considerably more complicated, and therefore, more expensive to replace or repair than either DC generators or PM alternators.

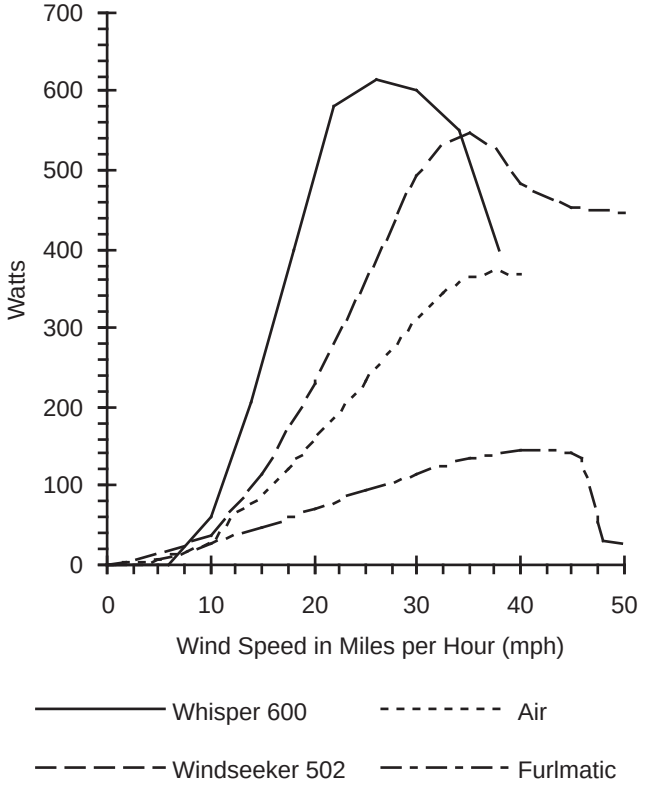
Tower Top Cost is the cost of the complete wind generating device. In most cases, it does not include the cost of any controls, except where noted in "special notes." Different end uses require different types of controllers, and some end uses don't require any controller.

$/Watt refers to the tower top cost divided by the rated output in watts. This figure is included so that you can make direct comparisons with the cost of PV panels.

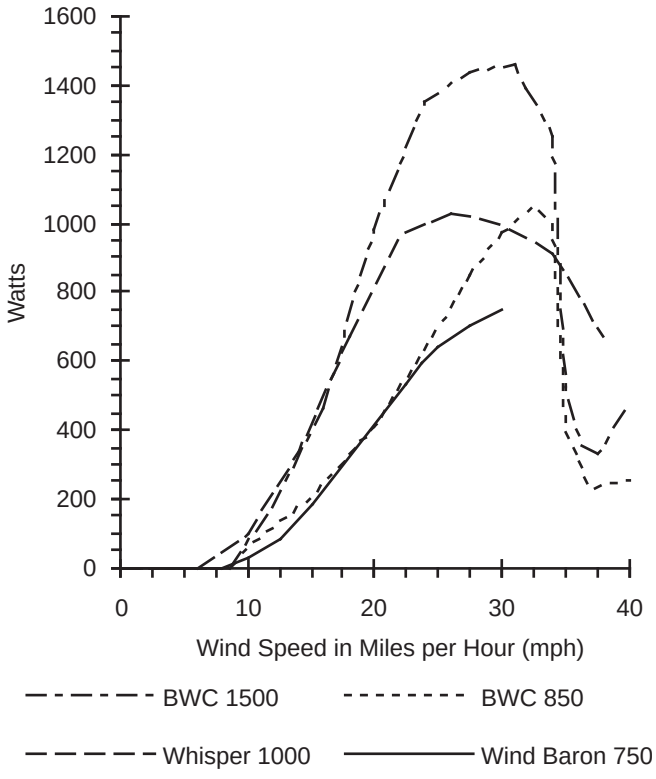
You must decide what the wind generator's end use will be. Different end uses will utilize different control systems, which are not interchangeable. **Battery Systems** is self explanatory. The voltages available for the battery systems are listed. **UTI Systems** refers to utility tie-in systems, that is, using the utility grid as your storage. **Resistance Heating** means that the wind system is used for space heating. These controls are the simplest and least expensive end use option. **Water Pumping** means that a control package is available to pump water with an electrical pump run off the wind generator directly. No batteries! This category designates whether an ac or DC pump is used. Because of the wide variety of controllers available, prices have not been included. Contact the manufacturer with specific needs and for price quotes.

Estimated Monthly Output at Sites with Average Wind Speeds of 10 mph and 12 mph is included so that you have some idea what a wind system will produce at your site. For comparisons, a very efficient home or small cabin would use 75 to 200 kiloWatt-hours (kWh) per month. The "average home in the U.S." (whatever that is) uses 600 kWh/month. An all-

Micro Wind Generators



Small Wind Generators



electric home would consume from 1200 to 2000 kWh/month, as might a small business or farm. The output estimates of the various wind generators are the manufacturers' numbers, not mine. Be aware that "your mileage may vary!" The number in parenthesis is the calculated capacity factor for the system based on estimated monthly output.

Capacity factor (%) refers to the amount of kiloWatts that the generator produces over a given period of time compared to its potential if it were running at full output all of the time. Note that different systems boast different capacity factors. Capacity factor for wind generators is a function of the swept area of the rotor and the rated wind speed of the system. Generally, the larger the swept area and/or the lower the rated wind speed, the greater the capacity factor.

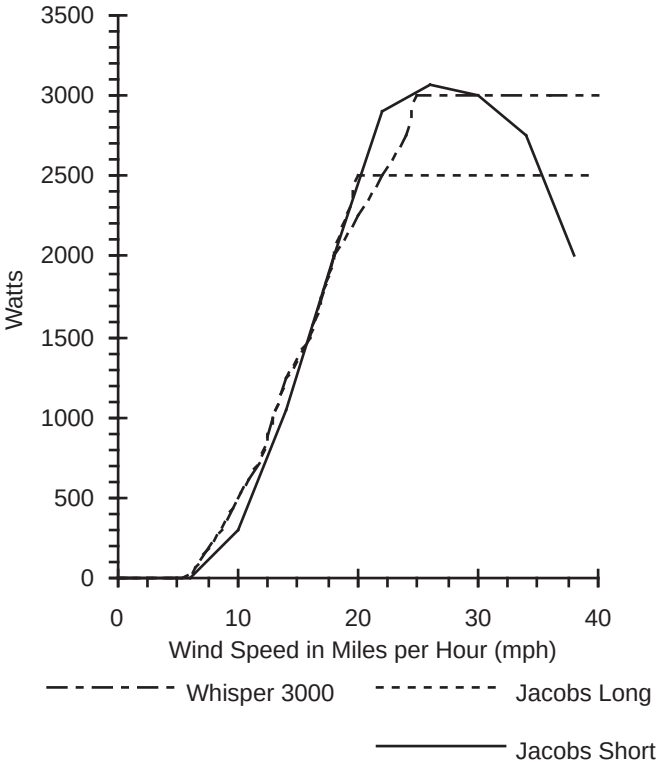
Warranty All the manufacturers warrant their products for parts and labor (that is, in-house repairs) against defects in materials or workmanship. This means that you must return the defective part to the factory for evaluation and repair or replacement at the discretion of the factory. Standard practice is that you will pay shipping both ways, just as with any other consumer good. Warranties do not cover improper installation, neglect, use of unauthorized components, abuse or "acts of God" (this is why you have homeowners' insurance). Manufacturer liability is for the defective part only, and does not include incidental or consequential damages.

Time in Business is included so that you can see that these manufacturers are not fly-by-nighters. All of these folks have established businesses and have done extensive business in the U.S. and abroad. Footnotes: (1.) While Wind Baron has been around for some 17 years, the wind generator they currently manufacture, the Wind Baron 750, has only been available for two years. (2.) Whisper wind generators have been available for only six years. Prior to that, the company was known as Whirlwind and manufactured a different line of wind systems.

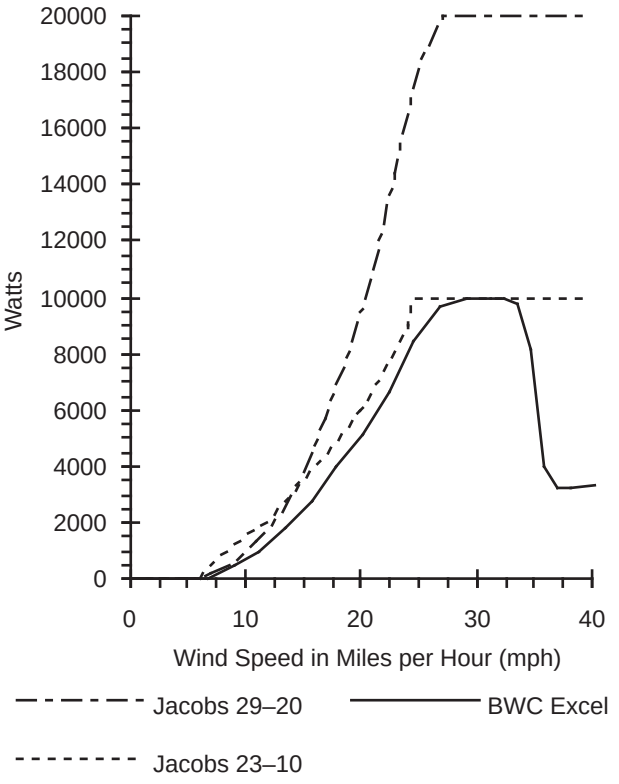
Routine Maintenance refers to what needs to be done to the wind generator to keep it in prime operating condition for a long life. How long? That's hard to say. Several years ago, I took down a Jacobs that had seen 60 years of nearly continuous duty. While the old Jacobs was certainly an overdesigned and overbuilt wind generator, properly cared for, any one of these systems could match that.

This doesn't mean that you will never have to replace parts or do some major repairs. Blades will need repainting and some new tape on the leading edge

Medium Wind Generators



Large Wind Generators



eventually. Bearings wear out and need replacing. Some systems, as noted, need annual greasing or oil changes. Bolts might loosen and need tightening. Adjustments might be needed here or there. It is unrealistic to expect something as complex as a wind generator operating continuously in a harsh environment to work flawlessly with no maintenance. If that's your expectation, then don't buy a wind generator.

Some manufacturers recommend only a visual inspection as their maintenance. Bergey Windpower Company, for example, suggests that after you install one of their units, once a year you need to go out to the base of the tower and look up to see if it is still running. That's it for another year! While there is no question that Bergey builds the most maintenance-free wind generators available in the industry, I am a little more conservative than they are.

Most of the catastrophic failures that I have seen over the years with various systems were due to something as seemingly inconsequential as a bolt loosening. I believe that the prudent wind generator owner should thoroughly inspect his/her system twice a year at a minimum; once on a nice fall day before winter hits and again on a warm spring day before thunderstorm season. As they say, prevention is the best cure! Preventative maintenance becomes more important as your investment in the system increases.

Most of the great strides in reduced maintenance have come not from new designs, but from new materials. The designs for today's wind generators have been around for a long time. For example, the side-facing governing mechanism used by Bergey and Wind Turbine Industries was patented in 1898 and originally used on waterpumpers. The tilt-up style of governing used on the Wind Baron 750, the Windseeker and the Whispers was patented in 1931. And the blade-activated governor used on the old as well as the new Jacobs was patented in 1949. However, such things as graphite-impregnated nylon used in some bushings or the aliphatic resin tapes that are used for leading edge protection were just being developed ten years ago. Continuous upgrading by incorporating modern materials in wind system components has helped greatly in the maintenance arena. The manufacturer who cuts corners by using cheap materials is courting trouble with customers.

Power Curves

The power curves for all of the wind systems reviewed have been put together so that you can more easily compare one system to another. The curves compare the power output of the various systems as a function

of wind speed. However, be aware that this is still an "apples and oranges" comparison. To use the PV analogy, it is better to compare all panels of a given wattage than to put all panels made on the same chart. The problem with wind generators is that there are not that many models available to choose from. Because some equipment outputs are close, some reasonable comparisons can be made.

Noise

Questions often arise about how much noise a particular wind generator makes. For the most part, a well-designed wind generator is relatively quiet. By the time the wind generator is cranking enough to cause some noise, trees are rustling and buildings are rattling as well.

Noise from a wind generator can come from two sources: mechanical noise and blade noise. Mechanical noise would emanate from something such as a gearbox. Most of the systems reviewed are direct drive, meaning the blade is coupled directly to the generating device. Only the 10 to 20 kw Jacobs utilize a gearbox.

Blade noises can be caused by two things: rpm and/or the airfoil. Rpm should be obvious. The faster something spins, the more noise it is likely to make. The shape of the airfoil can also have an effect of the amount of noise the blades make. As a rule, true airfoils are quieter than single-surface airfoils.

Installation

The installation of a wind generator on a tower can be accomplished with either the use of a gin pole or a crane. A gin pole is a type of boom that is mounted on top of your tower. Using cables and rigging, either the entire wind generator or its component parts are hoisted to the top of the tower, where they are installed. This is relatively easy to do with the smaller systems. However, only an experienced crew should attempt this with something as large as a 10 kW system. These wind generators are probably better installed with the help of a crane.

An alternative is to install a tilt-up tower. Tilt-up towers tilt down to ground level, where the wind generator can be easily installed and serviced. Tilt-up towers are generally more expensive than either freestanding or guyed towers.

Delivery time

A word needs to be said about the lead time required to get your wind system once you have placed an order. A wind generator is a very complex device made up of a wide variety of components and materials. All of the manufacturers represented here are small companies working with many subcontractors and suppliers. As such, they are somewhat at the mercy of events beyond their control.

Home-sized wind generators are not manufactured on an assembly line like many other consumer products. Instead, the "gennys" are made in batches ranging from a handful to a few dozen at a time. When you place an order, your machine becomes part of a batch. The manufacturer may already have a batch going that you can plug into. If not, your turn comes when the next batch is completed. As a customer, you need to be a little understanding about the lead time for the machine you order. In all likelihood, your machine will not be "instantly" available.

A few customers have had rather bad experiences with unusually long lead times. Some have felt that they have been "jacked around" by the manufacturer. While I can't say that this has never happened, I will defend the manufacturers as being pretty good guys on the whole. They really are concerned about satisfying their customers. After all, without you, they're out of business.

My Choice?

"So, Mick, what do you recommend?" is the most frequently asked question that I get. The answer: it all depends on your situation.

I can honestly say that, properly specified and installed, any one of these machines will do a fine job of producing electricity for you for many years. They all have their own personalities and idiosyncrasies, just like the cars we drive. And, just like the cars we drive, they come in a variety of shapes and prices. Finally, just like the cars we choose, they all will get us from point A to point B. However, not all cars, nor all wind generators, are created equal. As the saying goes, "you get what you pay for." Quality always comes at a price.

You now have all of the tools you need before you to make an educated choice. Make sure that you digest the facts and figures and assess your needs and pocketbook, so that you may choose well.

The Manufacturers

The manufacturers for the systems reviewed can be contacted for prices or more information. Or you can contact your favorite wind generator dealer.

Bergey Windpower Company, 2001 Priestly Ave., Norman, OK 73069 • 405-364-4212 • FAX 405-364-2078. Manufactures the BWC 850 and 1500 and the BWC Excel.

Lake Michigan Wind & Sun, E3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267 • FAX 414-837-

7523. Remanufactures the Jacobs “short case” and Jacobs “long case.”

Southwest Windpower, Inc., 1855 W. Kiabab Ln., Flagstaff, AZ 86001, 602-779-9463, FAX 602-779-1485. Manufactures the Windseeker 502, 503, and the AIR.

Trillium Windmills, Inc., Campbell Rd., R.R. #3, Orillia, Ontario, L3V 6H3, Canada • 705-326-6513 • FAX 705-326-2778. North American distributor for the Rutland Windchargers (which are manufactured by Marlec Engineering co., Ltd. of England).

Wind Baron Corporation, 3920 E. Huntington Dr., Flagstaff, AZ 86004 • 602-526-6400 • FAX 602-526-5498. Manufactures the Wind Baron 750.

Wind Turbine Industries, Corp., 16801 Industrial Circle SE, Prior Lake, MN 55372 • 612-447-6064 • FAX 612-447-6050. Manufactures the Jacobs 23-10 and 29-20.

World Power Technologies, 19 Lake Avenue North, Duluth, MN 55802 • 218-722-1492 • FAX 218-722-0791. Manufactures the Whisper 600, Whisper 1000, and Whisper 3000.

Access

Mick Sagrillo ruminates on wind generators at Lake Michigan Wind & Sun, E3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267


GoPower

On Assignment

Michael Hackleman

Been traveling a lot lately. Funny how I won't drive long distances anymore by myself. I love to drive, and I happily drive in a shared ride situation. But no one-person stuff. I always thought I'd lose some "freedom" by biking, busing, ridesharing, and hitching. Not so. It feels like freedom. It restores my faith that we can do this.

Before I share some travel experiences, I will summarize this issue's *GoPower*. I've described a new prototype in *ET Arrives at Home Power*. Trucks are a popular candidate for electric conversion because they are often already sprung for the added weight and they are designed for utility. Mark Parthe relates his experiences with a project in *Electric Pick-Up Truck*. Next is some Internet Q&A in *Net Cache*, your direct pipeline to GoPower. For the DIY (do it yourself'er) crowd, there's a writeup on *A HomeBrew EV Battery Charger*, an excerpt from my new EV book. Initially built as a backup, the unit has been the mainstay charger for my EV, has rescued many others, and has been used in a lot of other interesting ways. *GoPower* ends with Shari Prange's *Electric Vehicle Aerodynamics*.

On the Road

In March, I made plans to visit the HP office (Agate Flat, OR). Since Phil Jergenson (Willits, CA) was ready to deliver his production ET (Electric Tractor) to the HP site, I decided to bus to Willits from Santa Cruz and ride with Phil the rest of the way to Oregon.

I love to visit Willits. I am there each year for SEER and REDI, but I've longed for more. Phil and Richard Jergenson are old friends. Together, they were the core group in the early years of SEER. Since Phil had asked for help with ET on the wiring, I figured a one-day layover. Compliments of late winter storms, the number was four days. I didn't feel stuck! Instead, I further explored Summit, a privately-owned, mellow California microclimate, with its own rail service to and from town! The Jergensons want to make it a solar village. Good vision, perfect land, good location. Snowbound, I whiled away the hours in Richard Jergenson's library, which houses a three-quarter-century collection of *Popular Science* and *Popular Mechanics*. It was a blast to read the *PS* that came out the month of my birth.

Finally, a weather wormhole opened up between Willits and *Home Power*'s place and we zipped through. The roads were a mess everywhere (yeah, right, CalTrans, blame the weather!). An ominous-looking detour around a major slide mid-journey became a magical two-hour tour through beautiful high forest. We camped at Bob-O and Kathleen's house, a sort of halfway house for city'fied folks wanting to avoid those "hard landings" on Agate Flat.

We went up the hill in the morning. ET was the focus of attention, of course. The dog found it riotous, a dozen cats gave it a once-over, and the horse stared.

A variety of vehicles, like this Horlacher prototype, will be available at REDI Conference'95

Dr. Richard Green, Cal EPA, speaks at REDI Conference '93

Summit is an official stop on the SkunkTrain line

Home Power has decided to publish my EV book. I'll work in the HP office to lay out the EV book. My partner, Donna, confirmed her willingness to work for HP so that we could be together. I zoomed back down to Ben Lomond. We sublet the house for four months, bade friends goodbye, and packed the car. Driving up, the sky and sunlight showed us many faces of big tree country. We stayed overnight with Bob-O and Kathleen. Donna gave Kathleen a solar car for the PV-powered dollhouse she's designed and is building!

REDI Work

I've been asked to work with REDI this year. REDI is the Renewable Energy Development Institute. On the surface, the REDI Conference is the odd-year event in Willits, with SEER (Solar Energy Expo & Rally) the even-year event. REDI Conference '95 will focus on transportation (That's my side!) and solar issues. This year, we want to get fleet people together with people already manufacturing EVs. If you have plans to work in the EV industry, this is a good time to hang with people that are doing it and people who will need EVs to meet 2% ZEV mandates in 1998. REDI is not an exposition, nor is it open to the general public. The hobbyist may find the weekend ($125) or 1/2-day ($50) rates a bit steep. Still, REDI will gather together some very sharp EVs. Want more info? See Access (below). If you have something to contribute in the area of transport, contact me through the REDI office.

Access

Michael Hackleman, POB 63, Ben Lomond, CA 95005

REDI, 733 South Main St #234, Willits, CA 95490 • 707-459-1256 • Fax 707-459-0366

Phil & Richard Jergenson, PO Box 1029, Willits, CA 95490

Organic horse meets electric horse

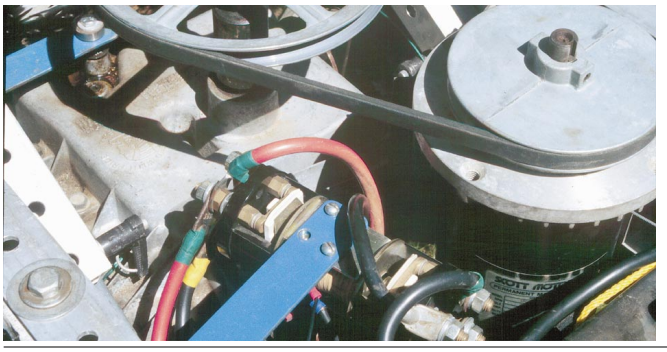
Phil demonstrates the tiltbed

ET Arrives at Home Power

Michael Hackleman

Phil Jergenson wanted something that could move around material of any kind—earth, machinery, building materials, etc.—on his homestead. It had to be strong, quiet, and able to handle rough terrain. Consequently, he designed ET, an Electric Tractor built around SunTool's BoxBeam™ materials.

HP ordered an ET and I watched Phil build it. For maneuverability, Phil kept ET's wheelbase short and went wide for stability. A heavy-duty, cast iron transaxle yields an overall 150:1 ratio for traction in low gear, and there are three more forward gears and one reverse. A V-belt couples the motor output with the transaxle's input pulley (photo). Owners may adjust the speed range of their vehicles (swapping out the input pulleys) to meet the demands of terrain and application.



Two batteries feed the PM (permanent magnet) motor, yielding one horsepower at 12VDC and 2HP at 24VDC. Thus, the battery pack delivers the torque of a 6-8HP engine in blessed silence. To keep the retail costs low and ensure simple regenerative braking, Phil opted to use a series-parallel controller. The eight poles of the DPDT contactor are tricky to connect, so I agreed to help wire up ET. The final arrangement had one button activating a SPST contactor for the paralleled batteries (12V to motor) and a second button (with 1st button still depressed) energizing the DPDT contactor for series wiring of the batteries (24V to motor). Thus, one hand handles maneuvering, but the ergonometry forces two hands on the handlebars for speed. (Real cars should have something similar.) This also means *two* electric speeds for each mechanical one, forward *and* reverse.

The tilt bed is nicely integrated with the vehicle. Once released, it easily tilts and dumps its load. Tilting the bed provides access to the motor, drivetrain, batteries, and electrical control components. Phil proved ET's worth during a two-hour work period moving dump piles at the HP site. ET was up and down the hill more than a dozen times with 200 lb. loads. SunTools plans to sell an ET kit with stock BoxBeam™ construction.

I know that Richard Perez plans to add an inverter to ET's innards. This will make it a portable power station (120 vac) for use anywhere on the property. We will let HP readers know how ET fares through time and use.

Access

SunTools (Phil & Richard Jergenson), POB 1029, Willits, CA 95490 • 707-459-2624

Michael Hackleman, POB 63, Ben Lomond, CA 95005

Above: Mark Parthe converted this 1984 Dodge D50 pick-up to run on electric power. The cost of the conversion was $8000, including the used truck. Range is 75 miles and this truck has logged 8200 trouble-free miles since its conversion.

Electric Pick-up Truck

Mark Parthe

After working with the EV club at the college where I am employed and attending two years of the Tour de Sol (TdS), it was time to build an EV the way I wanted. I decided that my goal would be to enter the TdS for 1993. It was September and I didn't even have a vehicle to convert yet. Seven months to build one from scratch—a challenge I could not resist.

Starting Out

Ever want to convert a vehicle to electric power? You don't have to be a genius. Just have a few friends with tools and a garage with heat. Add a little magic and whalla... The idea for my own EV started out in Boston at the beginning of Tour de Sol 92. I saw Bob Matson's converted Dodge D50. After several weeks of looking, I found an 84 Dodge D50. It was dirty and engineless but seemed to have only mild rust. $300 later it was in my driveway. I decided to name the project Genesis, as it was my first true conversion.

Body work time

From Oct 92 to Feb 93, the truck was stripped down to its last bolt. The cab and box were removed from the frame. At that time, I decided to keep the overall looks as stock as possible. The box and cab rust turned out to be much worse than I'd anticipated. The damage was way beyond just a little bondo and paint. My best friend, Mike Maxa offered his new $2000 MIG welder for the duration of the project. I'd never MIG welded before but after an hour or so, I had it down pat. The driver's floor had to be completely replaced along with the rocker panels and some of the box floor. A low-mileage, rust free D50 was found at a salvage yard and became the donor vehicle for parts. The gas filler door was closed in, and all the box seams were MIGed closed and filled. Various custom work was done such as sunroof, rollpan and license plate recessed into the tailgate. After four hundred hours, the two pieces were headed to my brother-in-law's body shop for filling and paint.

Frame

While the box and cab were at the shop, I sandblasted the frame. I added three extra leaves in each rear spring and MIG welded the battery holders to the

frame. Finally, I painted the whole mess with special frame paint.

Drive Train Modifications

After talking with other EV owners, I decided to keep the factory clutch and pressure plate. I have since driven cars with and without a clutch, and a car with a clutch wins hands down for drivability. A Solar Car Corp adapter plate/coupler was modified and fitted to the D50's smaller transmission. We set the tranny in a cradle with the front spline shaft sticking up. The adapter plate was set on the tranny and leveled. A needle and thread helped us find the motor shaft's center. A little drilling and cutting here and there, whalla ... instant (15 hours) motor mount for the 9 inch Advanced DC motor. Freerunning showed no vibration up to 4000 rpm. With the help of four friends, the motor/tranny unit was carried out of the basement and set in the frame. Factory motor mounts were used. The motor was secured in the frame with a cradle style mount. Torque is controlled with an arm mounted to the top of the tranny. The other end is mounted to the frame via a rubber compression mount. This arrangement has proved to be completely trouble free.

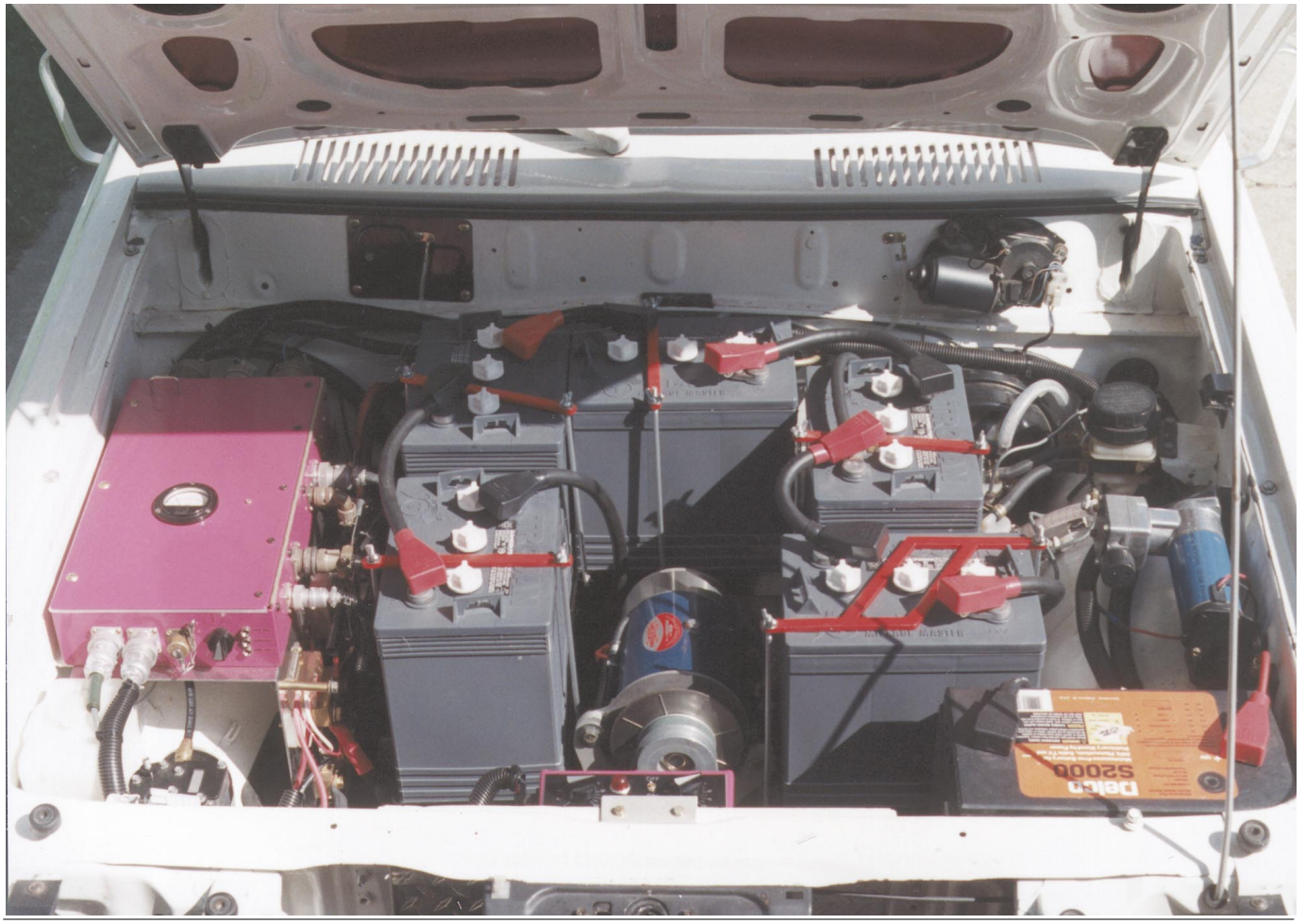
Brakes

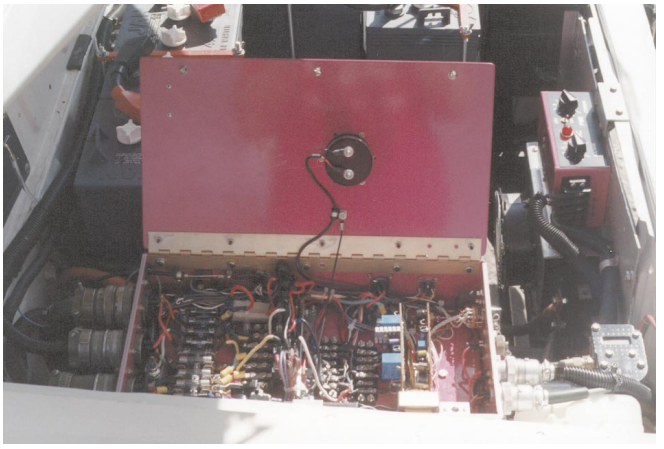
I made no modifications to the brakes. They have handled the extra weight without undue stress. A vacuum pump from Solar Car Corp provides suction for the booster. The vacuum cylinder provided with the pump was way too ugly to use, so 30 feet of braided Coca-Cola fountain hose were placed under the cab to run between the pump and the brake booster. It weighs a few ounces and has worked quite well. I can get six pedal pumps before the pump kicks in. It looks nice, too.

Box Lift

In order to service the batteries under the pick-up's box, I needed a lift system. Hydraulics were too heavy, so I fitted a set of airshocks to the frame 28 inches from the rear hinge point. The shocks have an 8-inch stroke and cost about $90 for a set. This gave the box a four

Below: Five of the batteries, along with the electric motor, regen generator, brake booster, and 12 V aux battery, are housed under the hood. The box (w/ meter on the top plate) contains the electronics.





Left: The electronics bay contains all fuses, relays, and control circuits.
The pulse charger is on the right fender. Air lift pump is located lower right.
Right: A close-up of the pick-up box lift air shocks. The 12 V batteries pictured here have been replaced with higher capacity, 6-volt Trojan T145s.

foot lift at the front. A small air compressor from a Buick Riviera was installed under the hood to supply air to the shocks. The whole system weighs only 10 pounds. This system proved to work extremely well. It takes about a minute to lift the box from full down to full up. A safety prop rod is used whenever I'm under the box working.

Batteries

On the advice of an EV conversion company, I purchased eleven US 1450, 12 Volt deep cycle batteries. Bench testing showed 62 minutes at 75 Amps. BAT fluid was added to them, but I really didn't see any change in performance. There was no time to change to larger capacity 6 Volt batteries. I put in the lower capacity 12 Volt batteries. Even with gentle driving, I only got about 35 miles' range. 12 Volt batteries are fine for light cars, but don't cut it for trucks. They just don't have the capacity needed for good performance in heavier vehicles.

Wiring

It was now the first week in March and the cab had just come back from being painted. I started the wiring in the second week of March and it took six weeks of evenings to complete it. I used nothing special in the wiring, except I made and installed a circuit for the factory tachometer. I used an auxiliary 12 Volt battery charged by two solar panels to provide the truck's 12 VDC systems with power. The motor batteries were

Below: Genesis awaits its turn on the fourth day of the Tour de Sol.

hooked up with 2/0 cable to a Curtis 1221 controller which in turn was bolted to a 1/4 inch aluminum diamond plate mounted in place of the radiator. I installed a shroud and fan around the controller to help keep it cool. Fuses, relays, shunts and a USAF surplus 400 Ampere contactor were installed on a plate bolted to the inside of the fender.

Regenerative Braking

Regen is provided by a Fabco AC generator custom wound for 180 volts. A 50 Amp diode does the DC conversion. A small bike brake lever, mounted on the gear shift, provides control. The cable from the lever pulls a microswitch under the hood that activates the Fabco's field. The Fabco is mounted on top of the Advanced DC motor with an aluminum plate and is direct coupled with a Kevlar V belt. Later tests showed it took 80 Watts per kiloWatt used just to freerun the Fabco. Instead, I have installed a clutch from Solar Car Corp. By downshifting, I get 30 Amps of regen down to 6 MPH with this setup.

Charging

Genesis is charged three ways. An onboard 220 volt pulse charger from Phazor is the primary charger. It supplies 22 Amps, has full control over current and voltage. It weighs 4 pounds. This type of SCR charger is very hard on connections, will make load panels buzz and will warm up an 8 gauge extension cord. At full current, it will pull 140 Amps for 20 milliseconds with a 0 current rest for 60 milliseconds. It also wipes out AM radio for blocks around. It operates fine with normal breakers, but as we found at the TdS, it will destroy a groundfault breaker. The Chrysler team had a factory-type pulse charger, and they trashed their breaker, too. Needless to say, the TdS people were not happy with us and have since put peak current limits in their rules. 110 volt charging is supplied by two Todd 77.5 volt units mounted under the seats. If all these don't work, a plug is provided under the hood for a transformer charger from Solar Car Corp.

Interior and Gauges

The interior was veloured by my wife, Shelly. Re-covered bucket seats were installed along with new carpet. A 0-300 ammeter from Fair Radio Sales was installed in the factory cluster where the old fuel and water gauge used to be. This makes any conversion look very professional. A Favin marine aux battery voltmeter and surplus 0-30 ammeter (for the charger and regen) were installed in the accessory gauge cluster mounted under the dash. Argonne Labs sent everyone a Cruising KWH meter for the 1993 TdS and this was mounted between the seats in a console. This is an invaluable device if you plan on any serious EV driving.

First Drive

Other than a few wiring errors, Genesis worked right out of the garage. I had only two weeks to test the EV before we left for the TdS but this was not a problem. At the TdS in 1993, Genesis's range with the US 1450 batteries was 30–40 miles, what I expected but still a big disappointment. Even with the short range, the truck was still a hit and many "great job, nice truck" comments were heard. Despite trailering a lot and ending up in the bottom third, our team was still a winner. Total cost to build from start to finish was $8000. All the labor except the bondo and paint was done by my wife and I. We drove the EV every day until late fall. I decided that if I was to be a contender in the 1994 TdS, a few changes had to be made.

Never Happy

During the winter of 93 (coldest on record), I removed the 1450 batteries. I welded up new battery holders for 20 Trojan T145 lead-acid batteries. I placed five batteries in front under the hood and fifteen in the frame underneath the box. I never liked the way I had wired the EV before, so I ripped it all out. I had an aluminum custom electronics box made so no open wiring showed. All connections in and out of the box were made using AN Style connectors. I also replaced all the 2/0 cables and used crimp post-style connectors with Kopr-Shield on the posts. This copper gel fills all the lead pores and reduces connector resistance. It's expensive but works very well. I also replaced the aluminum motor coupler with a steel one I had custom made for me. Despite adding 400 pounds, the range was increased to an honest 75 miles at 55 MPH. A 90 Amp motor draw is no problem. The total weight came out to 4050 pounds. It was 3650 pounds before conversion. Now we were having some fun!

Back to the TdS

At the 94 TdS, we proved to be quite the contender. Our team came in 12th out of 48 and 7th in our class. During one day, we achieved 102.5 miles on a single charge. No repairs had to be made at all during the race. Not bad for a backyard builder. Genesis now has 8200 miles of daily driving and every mile has been a pleasure. Other than watering and repairing a sticking regen brush, no other maintenance has been done.

Access

Mark Parthe, Shel-Marc Electric, 213 South Charles, Saginaw, MI 48602 • 517-793-9103. If you would like more information on Genesis or its systems, please contact me.

An EV Battery Charger

Homebrew

Michael Hackleman

A simple, variable-rate charger can be built for a few hundred bucks. It will fit battery packs ranging in size from 12V to 132V. The parts list is small and assembly is straightforward. I built mine for an electric vehicle.

Initially, I opted for a metal box (a recycled aluminum file carrier). This gave me the flexibility of using the charger for other applications (i.e., helping to give a friend a charge at an EV rally). Admittedly, it was more awkward to carry in the vehicle. Eventually, I realized how handy and reliable it was to use and re-installed it in the vehicle sidewall. Mounting a charger for a friend (Fig. 1) assured me that the side-by-side arrangement of charger and DC-DC converter would work in my own vehicle.

The first step is to acquire the parts and decide on an enclosure. There's nothing complex about the wiring itself (Fig. 2). Here are a few notes from building mine:

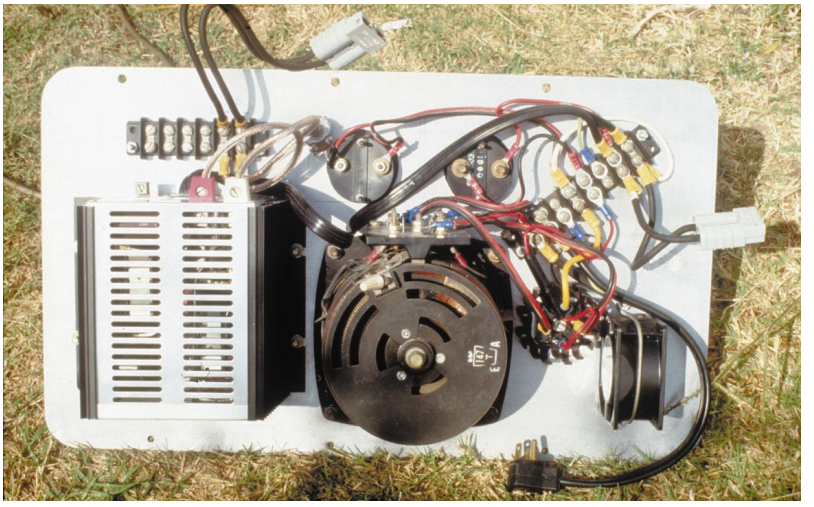
• Autotransformers (i.e.,Variacs) are expensive. Expect to pay $150 for a 15-amp unit. Double that for a 20-amp unit. Surplus houses usually know a Variac's value, so don't expect a good deal there. Shop around. Garage sales, contractor sales, and salvage operations of equipment are the best bet. It seems like a lot to spend, but check the prices of the alternatives!

• The sidewall ended up being the best home for the charger in my EV. The motor compartment won't work for this charger. While you can wash down the motor, controller, and any batteries in your EV almost any time, you must *not* get this charger wet. The trunk is a problem, unless you like opening and closing it frequently.

• Bolt the autotransformer to a metal (or aluminum) plate. This helps dissipate waste heat *and* secures the mount to the EV chassis. Wires attach to this unit, so you don't want the thing to "rotate" when you adjust its setting. Double check overall clearance, including the full rotation of the brush plate. If the brush touches anything in rotation, it will short out the unit or create a hazard by making the vehicle chassis "live." Insulate all metal within close proximity. Keep your brain engaged!

• Autotransformers are typically sold without the big knob that's used to adjust them. I spent a long time looking for a knob, was delighted when I found one, and used it for a few weeks before discarding it! True, no knob makes adjusting the autotransformer more difficult, since the shaft is small. However, this is good insurance that the unit is still adjusted to the *last* position you set it! Little and big people love to turn knobs. If anyone has been close to the charger, there's a *good* chance the setting has been changed. Up or down, that makes for a problem. Of course, you always have to dry your hands in order to adjust the knobless shaft. But that's always a good practice in the vicinity of electricity anyway! On the other hand, the knob lets you pre-select certain charge points (below) that can be marked on a dial plate.

• When I mounted my charger in the sidewall of the Honda VX, I wanted an unobtrusive cooling port. I used a speaker grill. I mounted the bridge rectifier to a heatsink position directly behind a 120 vac muffin fan. I selected the mounting of the autotransformer so that it was between the rectifier/heat sink/fan unit and the nearest exhaust port. Ergo, everything gets airflow and stays cool.



The Variac (right) and DC-DC converter (left) are panel-mounted. Use terminal strips for in/out power and instruments. Once installed, a cooling fan helps dissipate heat in the closed interior

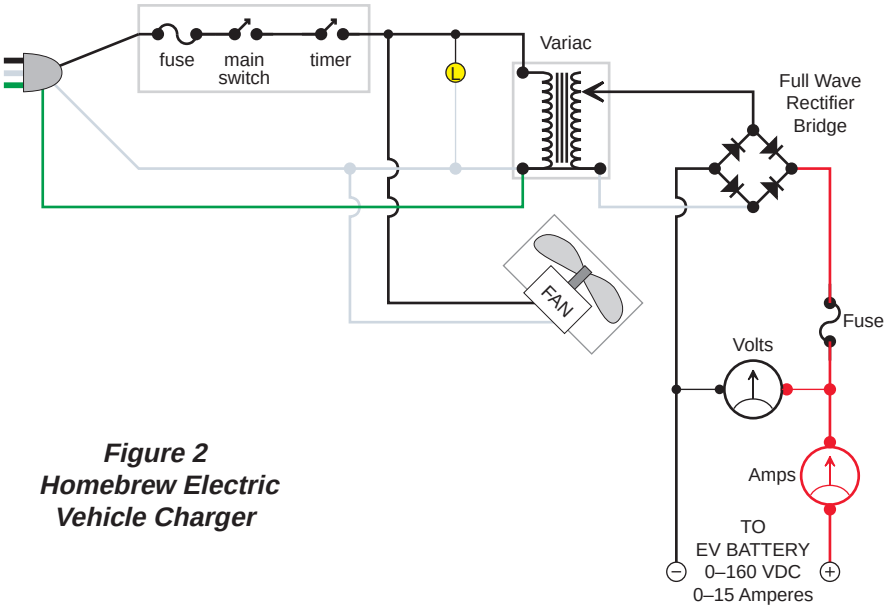


Figure 2
Homebrew Electric Vehicle Charger

Charger Parts

- Autotransformer (i.e., Variac). Input 110-120vac, 60-cycle. Charger output (adjustable) 0-140VDC. Units rated at 10A, 15A, or 20A. (Note: Transformer is *not* isolated. Use a GFI breaker for safety.)
- Full-wave bridge rectifier. Voltage rating: minimum 200PIV, maximum 400PIV. Amp rating should be *double* the maximum charge current you expect to use. A 200PIV, 35A unit will cost about $10 from electronic parts houses.
- Heatsink. Mounts the bridge rectifier, dissipating its heat.
- Muffin fan. Cools rectifier *and* Variac in enclosed spaces.
- DC Ammeter. 0-25A.
- Timer. 0-12 hours, 120vac.
- Fuse, primary. Rated 120vac, 125%of charger output.
- Fuse, secondary. Amps = autotransformer rating.

• An ammeter is handy. If you can get a small one, it can mount near the charger cord receptacle. It must be easy to see and check, particularly when adjusting the Variac.

• The timer is important. Whether the pack is tapering down, getting its equalizing charge or being fast-charged, a timer is the only thing that lets you walk away with complete confidence that you won't overcharge the pack. We are all absent-minded to some degree. You *must* have some sure-fire way to shut down the charge. At least, it saves on utility bills and minimizes adding water. Overcharging a pack will reduce its service life and might make it quite *hot*.

• This homebrew charger is not a constant-current unit. At whatever setting you make, as the battery pack is charged, the charge rate will automatically decrease. Where should it be set? Empirically, I have found three reference points on my charger (using a 15-amp Variac). Experiment to find similar points with your own application.

Point A. Initial charging for a depleted pack. Ensures that I do not exceed a 15 amp (indicated) charge rate initially. "Indicated" means the exact reading on the ammeter I'm using. Any more will cause the household circuit breaker to pop. This setting may be increased to Point B after 15-30 minutes.

Point B. Pack has been only partially depleted, or has finished an initial charge period. This setting allows the charge rate to gradually taper off to a 2-amp finish rate for my 120V pack. This is the walk-away-and-forget-it setting, or overnight charge setting.

Point C. The pack is ready for its weekly equalizing charge. At any point two-six (2-6) hours into the charge, I can adjust the charger to this setting, and the pack will be overcharged slightly, finishing at a C/40 rate (1/40th of the battery's capacity rating: i.e., a 100Ah battery will finish at 2.5 Amps).

• The Variac autotransformer is a strange breed. It acts like a transformer and yet its primary and secondary share a common ground. This means that 117 vac can piggyback the DC during charging. Use a ground-fault device if you're shy or have no savvy with electricity.

Final Thoughts

This is a low-tech, low-buck charger. Its efficiency is pretty good but not as high as a K&W or other types. Its brain is *you*. Mine is 10 years old and healthy despite the ways I've abused it. Besides being affordable, it easily handles all the experimenting I do. It has paid its way many times in service, and I wouldn't hesitate to build another.

Access

Michael Hackleman, POB 63, Ben Lomond, CA 95005

NET Cache

Michael Hackleman

Here are Internet items sent to me (and responses).

NiCds or Gel Batteries?

I'm still experimenting with an electric bike and it works very good now. I had to add a second motor to give it the power to climb hills. It has about 280 W/hrs of gel batteries. Do you think sealed NiCd cells have any advantage over the gels?

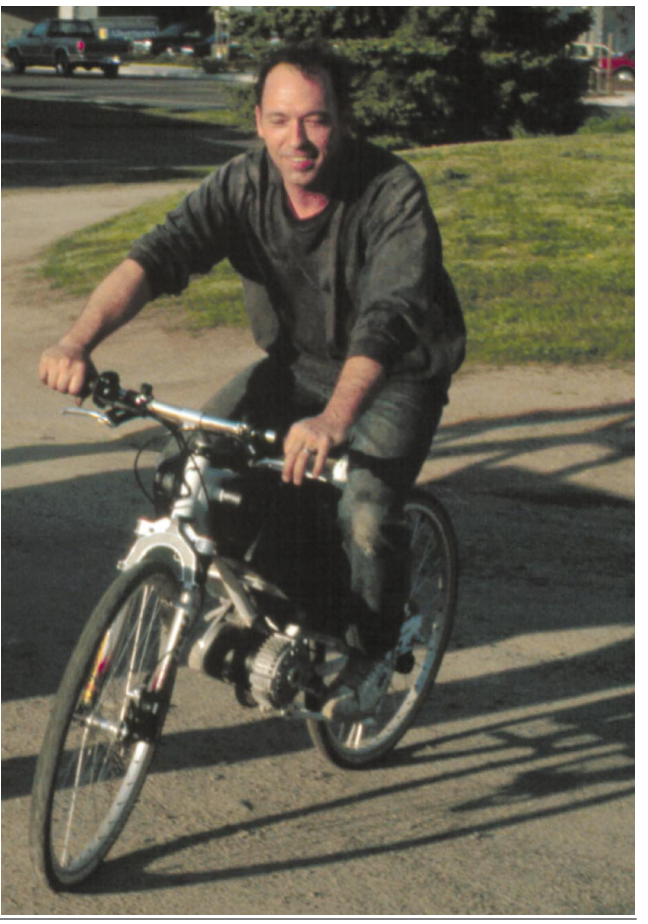
I am working on a potential project with a large bicycle manufacturer and will be spec'ing a design for them. The motor controller I built for this will handle up to 105 Amps continuous at 60 Volts (max component ratings). It fits on a 2"x 2" circuit board. The bike doesn't use anything near that on a continuous basis, more like 5 Amps at 30 Volts on level ground. I started using it as a moped to ride to work. Had to quit lately because of the rain. Gerald O' From: •email: god-rosa@cruz.com

Gerald, the only advantages I see in NiCds over sealed gel cells in this application are an increase in operating climes and higher charge rates. NiCds work better in cold weather than gels and can be recharged at rates that will spell a short life for a gel cell. The down side of NiCds is the lower energy density and higher cost. By weight, pocket plate NiCds have an energy density (Wh/lb) of 9.14 (and $668/Wh), where lead-acid gels are at 16.48 (and $375/Wh). The sintered NiCd fares better with energy density (12.5 Wh/lb) with a higher pricetag ($1,800/Wh). (These figures are from a table published in HP #17, page 34, comparing many battery technologies.) Where the end user of your electric bicycle lives in snow or needs fast charging, NiCds can be attractive. If the clime is mellow and lazy solar panels are the charge source, stick with gels. Further down the road, the NiMH (nickle-metal-hydride) technology will boost the energy density (23.75 Wh/lb) and reduce today's cost ($3,372/Wh) as it goes into production.

AC Drives

In your Stuck in Gear article in HP #38 you mention that Alan Cocconi "has systems for sale." Can you tell me how to contact AC Propulsion? I've been unable to find any ads or an address for Cocconi or AC Propulsion. I'm looking to build/buy an EV and am more interested in the more advanced technology of AC motors and controllers. Mike Bianchi

Mike, the last phone number I had for AC Propulsion is: (818) 914-4415. It's unlikely that you'll be able to chat with anyone, though. You are more likely to get in a couple of questions with Solectria or others concerning



their AC drives. While no match for the power capacity of Cocconi's systems, these AC drives are affordable, readily available, and reliable.

Battery Vehicle Society
Can I have an Email address for Tom Durrant from the Isle of Mann or can you please relay mine? I am a public relations officer for the Battery Vehicle Society (UK), and I would like details of the event he is organizing for the "Battery Vehicle Review." The society has 360 members with many vehicles. We would like to know if there is any way in which they could be involved. My postal address: Brian Hampton, #21 Bounds Croft, Greenleys, Milton Keynes, Buckinghamshire MK12 6AW, telephone 0908 316991.

Brian, I'll be happy to forward the mail. Meanwhile, here's your address for any other HP readers in your region of the world. Can we get a newsletter from you? Please encourage your members to submit article on topics in AE and transportation. Good photos are a must! Slides and other artwork will be promptly returned.

think of another place to send you for help. I wrote that chapter in my book first because the connection between bicycles and electric motors is important and there's so little info available. Anyway, a Scott/Doran (permanent magnet) motor may work ($200) and is available from some of the Electrathon suppliers. The 4.5 HP motor from Advanced DC Motors has the same weight, but more muscle and higher cost ($600 plus). Expect this motor (like any series type motor) to gobble electricity. Your final weight is similar to that of an Electrathon racer. So, look closely at the motors and gear ratios used in the winning designs. Good luck!

Wanna talk EVs?
(This notice was posted to me by Otmar Ebenhoech, at The Electric Speed Shop, (415) 494-9255)

The EV Electric Vehicle Discussion Mailing List is intended to provide a forum to discuss the current state of the art and future direction of electric vehicles. It is *not* intended to discuss either EV appropriateness or comparisons with other transportation primary drive modes such as the venerable internal combustion

The Sunrise prototype by Solectria uses an Induction AC Drive

This restored Aurenthetic motorcycle weighs as much as an Electrathon vehicle and uses a 1HP motor

Ely Schless demonstrates the PowerCycle, a production prototype resulting from his NoPed series

Electric Scooter
I am very interested in building an electric scooter. Something similar to the Eco-Scoot. I'm on a fairly tight budget so I am interested in ways to locate a used motor that would work. I am planning on using a Honda Spree body because I can get one for free. Can you suggest a better model? I have access to several. Can I get a good new motor for around $100.00? I am also interested in contacting someone who has done something similar. Thanks. GoPower is Great!!! Eric Guderyon. • e-mail to ejgudery@students.wisc.edu

Hi, Eric. My chapter on electric bicycles and motorcycles might help you with your project, but The New Electric Vehicles *won't be out until July. Can't*

engine. Those "discussions" are best relegated to the appropriate usenet newsgroup. The EV Mailing List currently has over 400 subscribers.

An electric vehicle is defined as any vehicle which uses an electric motor as the primary or sole motive force. The energy storage device used to drive said motor can use any technology including, but not limited to, solar electric, electric battery, fuel cell, internal combustion engine coupled with an electric generator (hybrids), or any combination of these.

To subscribe to the EV Mailing List, e-mail the command: *subscribe ev <firstname> <lastname>* to the Internet address: *listserv@sjsuvm1.sjsu.edu* or the bitnet address: *listserv@sjsuvm1*

After subscribing, you may enable the digest feature by sending “set ev digest” to the listserver. After subscribing, send messages to the list at: *ev@sjsuvm1* (bitnet) or *ev@sjsuvm1.sjsu.edu* (InterNet). The owner of this list is Clyde R. Visser, KD6GWN,• Email to cvisser@ucrmath.ucr.edu

And that’s all this issue!

Access
Michael Hackleman, POB 63, Ben Lomond, CA 95005. • Email to michael.hackleman@homepower.org

Otmar Ebenhoech • Email to tess@netcom.com

Electrathon America, Clark Beasley, 1251 West Sepulveda Blvd., Ste. 142, Torrance, CA 90502

This Pickette was delivered to the Hawaii Electric Light Company by Suntera, the Hawaii-based EV manufacturing company founded by Jonathan Tennyson

“And yes, I’ve checked my mailing label.”

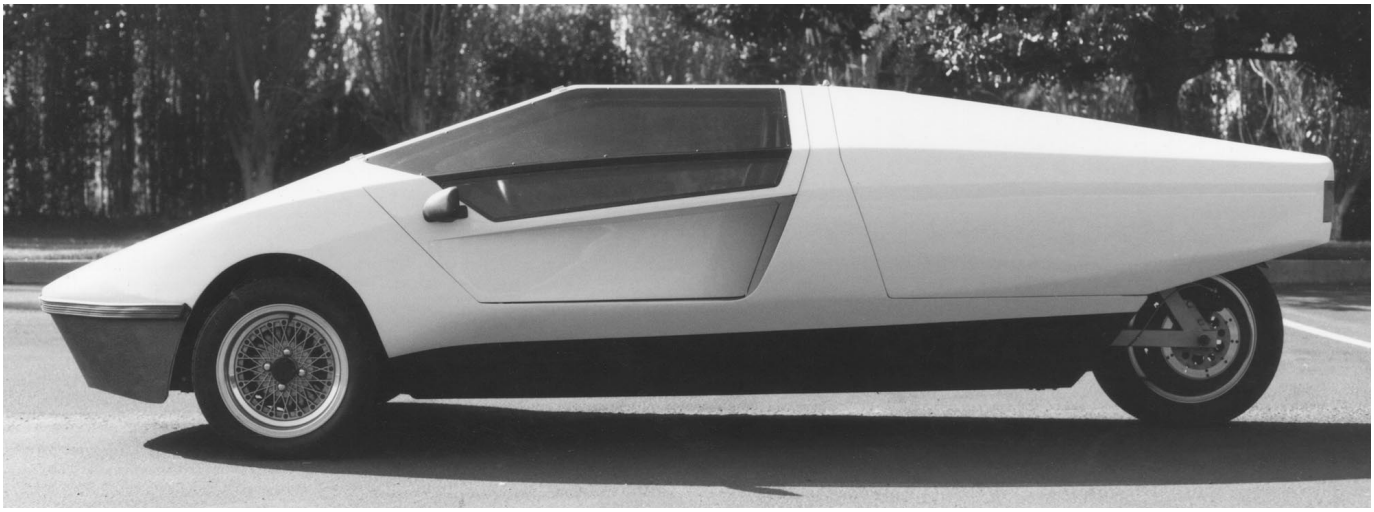
Rick Nemi, Morgan Hill, California

Don’t miss an issue of Home Power. The last issue of your subscription is printed in plain English on your mailing label. Check it out!

SNORKEL STOVE CO
3.4 wide
3.4 high
black and white
camera ready

CARRIZO SOLAR
7.125 wide
3 high

black and white



Above: The Vortex, from Dolphin Vehicles, is built with a slick aerodynamic body.

Electric Vehicle Aerodynamics

Shari Prange

If you've ever tried to drive a square, flat-nosed van or truck into a headwind, you know how much drag there is in mere air. You can feel the vehicle struggling, as if trying to push through a wall of Jello. Even a typical subcompact car, which is much more aerodynamic than a van, spends about 35% of its energy overcoming aerodynamic drag.

Aerodynamic drag is an enemy of electric vehicles for several reasons. It limits your top speed. It decreases your range. And, by causing the vehicle to work harder, it means you draw more current, and components run hotter.

For in-town driving at low speeds, a vehicle's aerodynamic characteristics are not very significant. But most of us do a portion of our driving at speeds of 45 mph or greater. Since drag is calculated by the velocity squared, even a small increase in speed greatly increases the effects of aerodynamics.

If you have the option of building a car from scratch, of course, you can optimize the aerodynamics, and you may end up with something that looks like the GM Sunraycer: a low, smooth, teardrop.

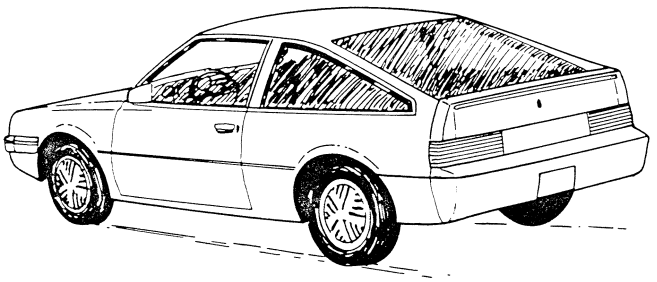
Unfortunately, few of us have that option. Even if we did, the Sunraycer shape is not practical for many of the things we need to do with our vehicles.

If we understand the principles involved, though, there are a lot of simple things we can do to improve aerodynamics and thus performance.

Form Drag

Form drag refers to drag caused by the shape of the vehicle. Of course, when you are shopping for a donor car, you must first consider what you want to do with it: commute alone, carry kids to school, carry maintenance tools and materials around a worksite, etc. The vehicle mission will determine whether it is a sports car, sedan, or pickup truck.

Once that is decided, however, look for the model that most nearly resembles a teardrop, with a rounded nose and tapering tail. This shape minimizes form drag.



Above: A fastback body-style is more aerodynamic than a squared-off rear window and trunk.

A squared-off trunk is just as bad as a squared-off hood. It creates a “negative pressure” area behind the car that pulls backward on it. A fastback is a good shape.

In general, the more modern the chassis, the more aerodynamic it is. Even very subtle changes in rounding the nose or adding small strategic flares will make one model of car much more aerodynamic than the previous year’s model.

Most of us are not free to choose the perfect chassis for conversion. We have to make do with a compromise that fits our budget and driving needs. However, there are still things we can do.

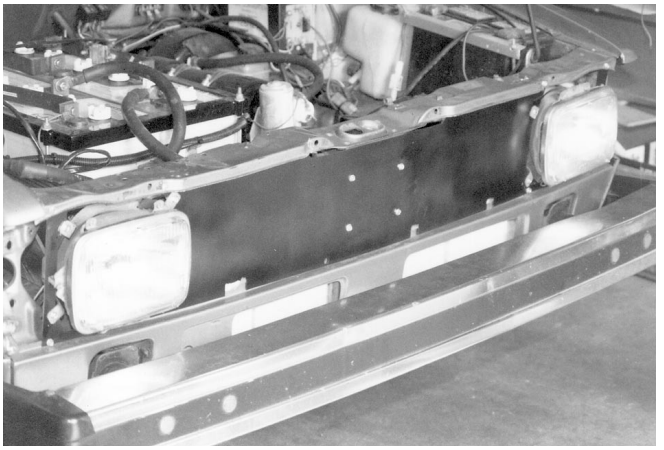
Included Drag

Electric cars have an innate advantage over internal combustion cars in that they require much less cooling. This is because they operate much more efficiently and waste little energy in the form of heat. Much of the drag in gas cars comes from the necessary flow of air across the radiator. Once that air enters the engine compartment, it creates turbulence and drag before finding its way out again.

In an electric car, we can close off the entire front grill area, because we don’t need all that airflow. In fact, you might be able to block it partially or completely with a sturdy plate of aluminum and mount your controller on the inside of the plate. Presto! Aerodynamic enhancement and superb controller heatsink, all in one.

If you don’t use this technique, you will need to be sure your controller and motor are still getting airflow. You may want to do this with a duct that channels air directly where it is needed or even with a small fan to provide forced air.

Below: This Voltsrabbit uses a grill block-off that improves aerodynamics.



Air also finds its way into the engine compartment from below. Since we no longer need constant access for oil changes, we can bellypan the engine compartment. This is also a good idea for protecting the motor from dust, gravel, road splash, and winter road salt and sand.

Any smooth, sturdy, lightweight sheet of material can be fastened under the car to serve as a belly pan. The engine compartment is the most important area to cover, but any area that has protuberances and depressions will be improved by a smooth cover.

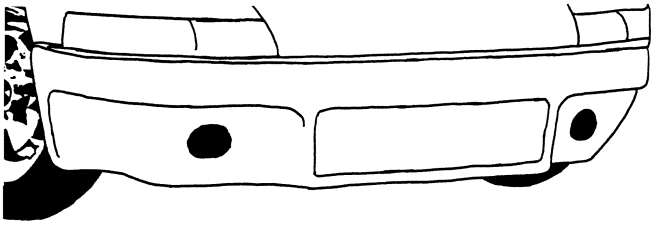
Don’t weld, epoxy, rivet, or otherwise permanently install the belly pan. Make it removable. What happens when, someday, you need to change the clutch, or the motor brushes?

Ground Clearance

Formula race cars have so little ground clearance they can bottom out over a deep shadow. That’s because hugging the road surface reduces aerodynamic drag. Those cars are also confined to smooth, well-tended race tracks.

Unfortunately, our cars must contend with potholes and speed bumps. But we can simulate that low ground clearance with aftermarket add-on kits. These include chin spoilers and side skirts. A chin spoiler is a plastic piece that extends from the bumper down close to the road. It causes the air to split smoothly and go around the car rather than under it. Side skirts cover the area between the front and rear wheels.

Below: A chin spoiler



A couple of words of warning are in order here. A little care is necessary when shopping for these items. Some models have been carefully designed to truly enhance the car’s aerodynamics. Others are merely intended to enhance the driver’s self-image.

Some care is also required in driving. Although these pieces are generally made of a tough plastic with a certain amount of “give” to it, speed bumps and parking blocks will beat up a chin spoiler.

Angle of Attack

We have talked before about the importance of restoring the car’s original ride height by careful weight

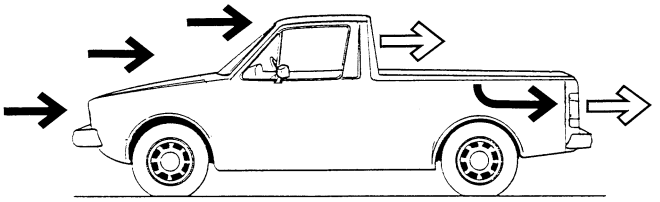
distribution and suspension modifications. This is important for good handling, which affects safety, and for proper alignment, which affects range.

It is also important for aerodynamics. The airflow over, around, and under the car can be changed significantly by very small alterations in the car. A hood that sits an inch higher or lower than it did originally will change the drag on the car.

The most common error in conversions is gathering all the components together in one nice big box under the hood, leaving little or no room for batteries. The batteries are then placed in one lump in the rear of the car. Then, to add insult to injury, no modifications are made to the suspension. The car drives with its nose in the air and its tail dragging. It handles like a pig on ice—and has about the same coefficient of drag.

Pickup Trucks

The newer pickups have much more rounded noses. However, the biggest drag factor is the pickup bed and tailgate. Airflow forms negative pressure areas behind the cab and tailgate that pull on the truck. In addition, air gets inside the bed and pushes against the tailgate from that direction.



Above: Aerodynamic drag includes positive air pressure (black arrows) and negative air pressure or partial vacuum (white arrows).

A streamlined cap on the truck bed will improve the airflow. If you can find them, you can also add anti-dirt flares to the back of the cap. These are little add-on flares that are sold to keep the back of pickup caps and vans cleaner. However, the reason they work is that they subtly alter the airflow and break up the negative pressure area behind the vehicle. Without them, the air swirls up and back onto the rear window, carrying a sticky fog of exhaust (in gas cars) and road dirt.

A less costly option for a pickup is a tonneau cover for the bed. This is a durable fabric cover that snaps across the top of the bed and encloses it. This keeps airflow from getting inside the bed.

A third option is replacing the solid tailgate with a net, which allows air to flow through. Don't make any irrevocable changes, however, like throwing away the original tailgate or cutting it off if it can't be unbolted. Someday you may want a solid tailgate behind the load you're carrying.

Every Little Bit Helps

The overall performance of the electric car is the sum of dozens of small factors. Don't wait for a "miracle" battery that's "just around the corner" to make miraculous improvements in your car's performance. Instead, a little attention to detail can make your car a star performer today.

Access

Shari Prange, Electro-Automotive, PO Box 113, Felton, CA 95018 • 408-429-1989

Things that Work!

Things that Work!
tested by *Home Power*

Staber System 2000 Washing Machine

Bob-O & Kathleen Jarschke-Schultze

There is a small revolution going on in the appliance industry that has manufacturers scrambling. More and more buyers are demanding less and less. Less energy consumption and fewer expensive components to wear out and replace. Add to this the very real possibility that the US Department of Energy (DOE) will soon be mandating high efficiency standards that most of today's top loading washers can't meet. The Staber System 2000 washing machine not only exceeds the DOE standards, but is compatible with modified-sine wave inverters!

Ye Old Washing Machine

Until now, there have been just two types of washing machine design, the top loader and the front loader.

Top loading machines are big. They hold a lot of clothes and use a lot of water. The average water consumption per load for current machines is about 43 gallons and some use well over 60 gallons. It takes a lot of energy to pump and heat that much water. The machines need a lot of soap to get the clothes clean and the resulting waste water needs more treatment before it can be recycled. The clothes sit in the tub of water and are moved with a paddle-like agitator. Since the clothes and the agitator are always in direct contact with the water, it takes a good deal of energy to move them back and forth and circulate them within the tub for good cleaning action. Top loaders require an energy-eating transmission, clutch, and mechanical brake to shift between wash and spin. Any load imbalance, such as all your Levis on one side of the tub and your T-shirts on the other, tends to make them do the jitterbug across the floor.

Front loading machines tend to be smaller. They don't hold as many clothes as the top loaders. The loading door is actually part of the tub and needs to press firmly against a rubber seal to keep the water, soap, and clothes in. Once you start a load, you're pretty much committed. The drive pulley and belt are in the rear of the machine. The clothes basket is driven and basically supported by the rear bearing since the loading door is where the front basket bearing should be. This design anomaly and leaky door seals have led to repair frequencies of front loaders far higher than those of top loaders.

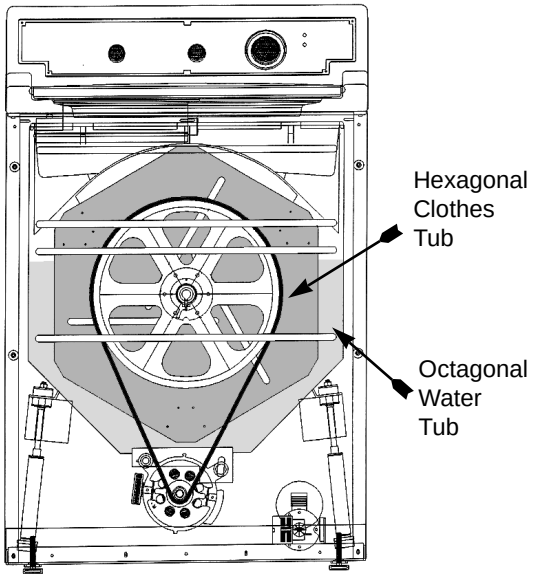
On the bright side, front loaders use less than half the water and soap of top loaders. Since the clothes tumble through (but are not immersed in) the water, it takes less energy to move them around and load imbalances tend to sort themselves out.

The Staber System 2000 H-Axis Washer

The Staber H (or horizontal) axis washing machine combines the best features of the front and top loading machines and adds a few of its own. It is essentially a front loader washer with the door on top! This allows the clothes basket to be supported by shaft bearings on both sides and the drive pulley and belt assembly to be located at the front of the machine for easy access and service. The design also allows clothes to be added in mid-cycle, impossible with a front loader where the door forms part of the outer tub.

The active electrical components are the efficient DC drive motor and an electric water pump. That's it! The motor is controlled by an electronic module which provides motor reverse for agitation and speed control of spin and wash cycles. A safety interlock door-latch prevents opening the machine until the clothes basket is fully stopped. The octagonal outer tub and the perforated hexagonal inner clothes basket are made of stainless steel and warranted for 25 years. The six-sided clothes basket rotating inside an eight-sided tub is a very ingenious design. It actually causes a

Cut-away view of the Staber System 2000 Washer



pumping action which forces the water through the clothes basket and agitates the clothes. The System 2000 spins at a higher RPM than most agitator washers. Faster spin cycles extract more water which leads to less drying time.

Power and Resources Consumption

We tested the Staber HXW2300. It's their top of the line residential model and features a prewash cycle, soap/bleach dispenser, different wash/spin speeds for delicate and permanent press clothes, and a two-level water control. The chart pretty much speaks for itself. With an average electrical consumption of about 250 Watts per load, the Staber is an extremely efficient machine. Most top loaders consume twice that. Half the water consumption also means half the energy used to pump and heat the water.

Staber Industries recommends that you don't use any soap the first two times you wash your clothes. I put the drain hose into a bucket to see what the wash water looked like. Besides all the dirt that came out of the clothes, there were also suds from the soap residue of earlier washings. I used about 1/4 cup of liquid soap after that. Then Bob-O wanted to run the machine with no clothes in it to see the power draw when empty. He didn't look inside first and rewashed a load (without soap) that was still in there. More suds. Even 1/4 cup soap is too much for normal loads. Now I use 1/8 cup soap per load.

The System 2000 Off-grid

We tested the Staber machine with all the inverters we had. It performed well with both sine wave and modified sine wave inverters. It ran just as well on a small 500 Watt Exeltech as it did on our 4 kW. Trace. We're pretty confident it will run on any sine or modified- sine wave inverter over 600 Watts or so. One reader reported it ran great on her Trace 724. This is great news for the thousands of off-grid users with modified sine wave inverters.

Ain't nothin' perfect...

Our test machine arrived with a good sized dent in the housing due to the shock-mounted tub shifting in transit. Staber Industries *immediately* took steps to correct the problem, reinforcing the housing to prevent future problems. This is one of the great advantages of dealing with a small company versus a giant "Appliance-O-Rama" firm. Responsiveness. There have been no new reports of shipping damage.

Staber Industries System 2000 Washing Machine

Inverter Used	*Load lbs.*	*Wash Cycle*	*Water Level*	*Water Temp.*	*Time (min.)*	*Ave. Amps*	*Watt Hours*	*Peak Amps*	*Water Used*
Trace 4024	0	Reg. 15min.	High	Cold	45	2.44	214	5.36	21
Trace 4024	13	Reg. 15min.	High	Cold	45	3.28	288	7.76	22
Trace 4024	8	Reg. 15min.	Low	Cold	44	3.54	304	8.00	18
Trace 4024	16	Reg. 15min.	High	Hot	46	3.01	270	9.52	22
Trace 4024	8	Reg. 15min.	Low	Warm	43	3.35	281	7.60	17
UPG 1300	4	Perm. 15min.	Low	Warm	43	2.33	195	5.20	17
UPG 900	12	Reg. 15min.	High	Warm	45	2.55	224	6.40	21
Trace 1524	11	Reg. 15min.	High	Warm	45	2.98	261	7.52	22
Trace 1524	10	Reg. 15min.	High	Warm	45	2.54	223	6.64	22
Exeltech 500	11	Reg. 15min.	High	Warm	No data taken				

Average Watt-hours per load **251**

A minor problem occurred during testing when we tried to start a load with an inverter in "sleep" mode. The electronic module opened the fill valves and started the machine's timer, but wouldn't start the motor. We thought, "Uh-oh, we've fried it." Nope! Unplugging the unit reset the control default parameters and everything worked fine with the inverter in the full "on" mode. We recommend bringing your inverter out of sleep with a small load to avoid this inconvenience.

Comes Out in the Wash

We have washed everything in this machine. Besides our regular laundry, which is pretty dirty, we have washed dog blankets, bathroom rugs, hall runners, quilts and Bob-O's work clothes. This machine really cleans the clothes. I think they are cleaner than I've been getting at the laundromat, and with less soap.

Our method has been to sort the clothes, then stuff the clothes basket full to the top, so that when I use both hands to close the basket I am actually pushing the clothes in. This machine loves a full load. I did a light load just to see how it worked. It worked fine, but actually used more electricity! I have enough laundry that light loads are not the norm around here.

The Staber, like most washers, is a loud machine. The laundry area is right outside my office in our basement so I can hear it pretty well. However, it does not bother me in the least to hear a machine doing work for me that otherwise would be a much bigger chore. If your laundry is done in your kitchen, noise *might* be a consideration for you.

Lid Lock

When the machine is running, a green Lid Lock light comes lights up on the control panel. It is a safety feature. Say you drop some loose socks on the stairs and have started the load before you find them. All you have to do is: Stop the machine wherever it is in the cycle. When the Lid Lock light goes out (about two minutes), you can open the lid, then the basket, and add the socks. Close the basket door, then the lid, press the dial in and the wash cycle continues.

About four times now, that light has stayed on past the two minutes when the complete cycle is done. The lid did unlock. I unplugged the machine, counted to five, plugged it back in—and the light went out. This could be entirely avoided by having the machine on a fused plug strip. Staber acknowledges the glitch and is working on a fix. It's really a very minor flaw.

Conclusions

I really like this washer. The molded, textured plastic one piece lid is an attractive piece of engineering. It looks good, wipes clean and won't chip. When the lid is closed, the Staber looks fairly regular. I love opening it up to show it off. The underside of the lid is molded to fit snugly over the stainless steel tub. The tub has two flat sides that open. There is a sensor that always stops the tub so that the opening is at the top. There are a minimum of parts, and each has a purpose—and that purpose is performance. It's excellent.

There are three models of the Staber System 2000 H-axis washers for the home user and a commercial coin-operated model. The price range is $799-$899 cash price for the home units, and $1,099 for the commercial coin-operated machine. Freight is additional.

This may seem like a lot of money for a washing machine. Given the quality construction throughout and factoring in the energy and resources saved over the machine's lifetime, it's a bargain.

Access

Authors: Kathleen Jarschke-Schultze and Bob-O Schultze c/o Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-0830

Manufacturer: Staber Industries, Inc., 4411 Marketing Place, Groveport, OH 43125 • 800-848-6200

Top: Wind workshop students prepare to lower the wind generator. Bottom: Mick Sagrillo discusses raising a tilt-up tower.

MREA Workshops:

Get Efficient and Go Renewable!

Kurt Nelson

The Midwest Renewable Energy Association (MREA) is a non-profit, grass-roots organization based in Amherst, Wisconsin. The mission statement of the MREA is to promote renewable energy and energy efficiency through education and demonstration. Because education is the primary vehicle of change (and change is certainly needed), I wanted to up-date you on some recent MREA activities. I also want to encourage you, individuals and organizations alike, to enlighten and educate others. Education and change!

Since its inception five years ago, the MREA's annual Energy Fair has been the primary focus of the organization. Over the years, the Energy Fair has grown substantially, and this year's three-day event will offer over 85 workshops (see display ad, this issue). In 1994, the MREA expanded its scope by announcing the creation of a new educational institute. The goals of the Midwest Renewable Energy Institute (MREI) are multifaceted and will amplify current MREA outreach programs. The creation of the Educational Institute also adds fuel to the MREA's permanent location 'fire'—our search for a permanent site in the Amherst (WI) area on which to build a better Energy Fair as well as to house the Institute sessions. We will even offer on-site camping some day.

Our goal is to offer extended workshops throughout the year. We can't fit all our educational projects into a single Energy Fair weekend. These 'continuing education' workshops are one to three days in length and offer a more in-depth and hands-on educational experience than those offered at the Energy Fair. In addition, they offer an environment where those in

attendance are better able to socialize and network with classmates and instructors alike. Throughout the late summer and fall of 1994, the MREI offered eleven of these one, two and three-day workshops.

Workshop Antendees Speak!

Alex De Pillis, Madison, Wisconsin, is the project administrator for Energy Islands International Inc. He develops wind/solar hybrid systems and consults in wind resource assessment. Alex attended two of MREI's workshops. One was a two-and-a-half-day 'Batteries and Inverters' workshop conducted by Richard Perez and Dan Lepinski of *Home Power Magazine.* The workshop was held at the University of Wisconsin's Treehaven facility, a 1200 acre education center in the beautiful north woods. The other, 'Residential Solar,' was a one-day workshop held in Madison, Wisconsin conducted by Doug Steege of Altech, a firm specializing in solar thermal. Alex wrote, "Both workshops I attended offered the opportunity to view the equipment, see it in action, and to even get product cut sheets and other special information normally available only to authorized dealers or researchers."

According to David Knapp of Winnebago, Illinois, "It wasn't until I attended these workshops that I started to realize how high technology and people relate to the grass-roots renewable energy movement. Perhaps more importantly, I learned that technology promoting clean living is accessible to everyone." David works for an aerospace company as an engineer. He writes software and designs test equipment to weed out manufacturing defects in printed circuit boards. He attended four of the Institute's workshops, including the two-day 'Home-Sized Wind Systems' workshop held in Forestville, Wisconsin conducted by Mick Sagrillo of Lake Michigan Wind and Sun (LMW&S).

John Root, of Dubuque, Iowa, wears two hats at the University of Dubuque. John spends his mornings as assistant to the University's Director of Computer Services, with afternoons spent developing programs that enhance the Environmental Policy degree offered by the University. He talks about the workshop he attended as a life-changing experience. "Years ago, when I sold and installed wind machines, I thought big was better. After attending the 'Batteries and Inverters' workshop, I believe less, used responsibly, is much better." John goes on to say that he has since taken his Kyocera PV panel "out of its closet" and put it to work charging a battery that powers his stereo, phone, and computer.

Jim Pardee is owner of Earthway, a company that designs and markets earth-sheltered homes. He has

Top: The PV class sets up a Wattsun tracker.
Center and Bottom: The Battery and Inverter class tested eight different inverters.

Top: The solar hot water class visits Packerland.
Bottom: The residential solar class at Altech.

incorporated many renewable energy technologies into his designs. Jim attended several of the workshops, including the 'Solar Domestic Hot Water' workshop held in Green Bay, Wisconsin and the 'Wind/PV Hybrid' workshop in Amherst, Wisconsin. The 'Solar Domestic Hot Water' workshop took place at Packerland Solar, the world's largest solar hot water installation, and was conducted by Richard Lane of Packerland Solar. The Hybrid workshop was conducted by two wind and solar experts. Jim Kerbel of PV Systems (the infamous J. Kerbel who conducts a pre-Energy Fair workshop every year, installing the Energy Fair's R.E. electrical system), focused on the sunny side of hybrids. Mick Sagrillo of LMW&S amazed us all away with his expertise on wind machines, rotors and towers. Mick boasts of having the tallest booth at the fair each year. His 80 foot tall 'booth' supplies much of the fair's wind-generated electricity.

Although shorter workshops, such as Bev Nelson's four hour 'Window Quilting for Moveable Insulation' workshop held in Stevens Point, only attracted Wisconsinites, this was not the case with some of the longer courses. Gina Quintana traveled from Pennsylvania and Akhiro Kuwahar came all the way from Massachusetts.

All and all, the first year of the MREA's Educational Institute's workshops was a great success and a lot of fun! We will keep you posted on this year's workshops and other MREA events in the "Happenings" section of future *Home Power* issues.

Access

Author: Kurt Nelson, c/o Midwest Renewable Energy Institute, PO Box 249, Amherst, WI 54406 • 715-824-5166 • Fax 715-824-5399.

Midwest Renewable Energy Association Educational Institute Workshop Schedule Fall 1995

September 9-10: Home-Sized Wind Systems
Instructor: Mick Sagrillo, Lake Michigan Wind & Sun
Location: Forestville, WI
Cost: $200

September 16-17: Introduction to Renewables
Instructor: Mickey Wurl-Koth, Solar Spectrum
Location: Treehaven Learning Center, Tomahawk, WI
Cost: $200

September 23-24: Photovoltaic Systems
Instructor: Jim Kerbel, Photovoltaic Systems
Location: Amherst, WI
Cost: $200

September 31 - October 1: Solar Domestic Hot Water
Instructor: Chuck Gates, Altech Energy
Location: Madison, WI
Cost: $200

October 7-8: Detailing for Energy Efficiency
Instructor: Mark Klein, Gimme Shelter
Location: Amherst, WI
Cost: $200

October 14-15: Wind/Photovoltaic Hybrids
Instructor: Mick Sagrillo and Jim Kerbel
Location: Amherst, WI
Cost: $200

October 20-22: Batteries and Inverters
Instructor: Bob-O Schultze, Electron Connection
Location: Treehaven Learning Center, Tomahawk, WI
Cost: $250

October 28: Residential Solar Energy
Instructor: Doug Steege, Altech Energy
Location: Madison, WI
Cost: $100

November 4: Insulated Window Covers
Instructor: Beverly Nelson
Location: Amherst, WI
Cost: $40

Significant Other can attend with partner for 1/2 price but won't receive additional handouts.

Call MREA for more information on these workshops

Glossary of renewable energy and battery terms

active material — The materials which chemically react within the cell to release free electrons are known as active materials. In most cases, one active material is a metal or metallic compound which is oxidized. The other active material, often a metallic oxide, is reduced.

ampere — The ampere is the standard unit used to measure electrical current. Physically, the ampere is a measure of the number of electrons passing a given point per unit time.

ampere-hour — The ampere-hour is the unit of measurement of the electrical capacity of a cell or battery. Physically, it represents the number of electrons available from the cell or battery.

anode — The anode is the electrode within the cell which undergoes the chemical process of oxidation. Electrically, the anode is the cell's positive terminal.

antimony — Antimony is a metallic chemical element with the atomic number of 51. Antimony is alloyed with lead to physically strengthen the plates of lead-acid cells.

battery — A battery is a group of interconnected electrochemical cells. Single cells are considered to be a battery if they are used alone.

capacity — Capacity is the amount of electrical energy a cell or battery contains. The ampere-hour is the unit of this capacity.

cathode — The cathode is the electrode within the cell which undergoes the chemical process of reduction. Electrically, the cathode is the negative terminal of the cell.

cell — The cell is the basic unit used to store energy in the battery. The cell contains an anode, a cathode, and the electrolyte.

cutoff voltage — The voltage level at which a cell is considered to be empty, and the discharge process is terminated.

cycle — A cycle is one complete charge/discharge sequence of the battery.

cycle life — Cycle life is the number of cycles a cell or battery will undergo before being considered "worn out." This point is usually defined as when the battery's capacity has reached only 80% of its initial rated capacity.

deep cycle — A battery or cell is said to be "deep cycled" if 80% or more of its energy is withdrawn before recharging.

dendrites — Dendrites are microscopic whiskers of metal which form in nickel-cadmium cells. These metallic whiskers may cause internal shorting within the cell, rendering it useless.

depth of discharge — The amount of energy withdrawn from a battery or cell expressed as a percentage of its rated capacity.

electrochemical couple — An electrochemical couple is two chemical compounds or elements which react together to release free electrons.

electrolyte — The electrolyte is the medium of ion transport within the cell. The electrolyte provides a path for electron transfer between the anode and cathode of the cell. Electrolytes are usually liquids or pastes, which are either acidic or basic.

end of charge voltage — The voltage level at which a cell or battery is considered, while under charge, to be full.

energy density — Energy density is a ratio of a battery or cell's capacity to either its volume or weight. Volumetric energy density is expressed in watt-hours per cubic inch. Weight energy density is expressed in watt-hours per pound.

energy transfer rate — The energy transfer rate is a measure of the rate at which energy is either being added or withdrawn from a battery or cell. This energy transfer is measured in amperes.

equalizing charge — The equalizing charge is a controlled overcharge of an already full battery to restore all the individual cells within the battery to the same state of charge.

float service — A battery is in float service when it is continually charged at a very slow rate, and only occasionally discharged.

gassing — Gassing is the evolution of hydrogen and oxygen gasses at the cell's electrodes. These gasses result from the hydrolysis of water in the electrolyte during the charging process.

grid — The grid within a cell is an electrically conductive structure which holds the cell's active materials. The grid may or may not participate in the chemical reactions of the cell.

hydrometer — The hydrometer is an instrument for measuring the density of liquids in relation to the density of water. The hydrometer is used to indicate the state of charge in lead-acid cells by measuring the specific gravity of the electrolyte.

ion — An ion is an electrically charged particle or molecule.

local action — Local action is the process of self-discharge that is present in all forms of electrochemical cells.

Isc — Amperes short circuit, usually applied to photovoltaic modules.

photovoltaic module — A series connected group of photovoltaic (PV) cells. PV cells make DC electric current directly from sunshine.

primary cell — A primary cell is an electrochemical cell which cannot be recharged. The chemical process within the primary cell is only one way—discharge. When a primary cell is discharged it is discarded.

rate of charge — The amount of energy per unit time that is being added to the battery. Rate of charge is commonly expressed as a ratio of the battery or cell's rated capacity to charge duration in hours.

resistance — Resistance is the property of materials to impede a flow of electrons through themselves. All materials have some resistance. Those of low resistance are known as conductors, while those of high resistance are known as insulators. The unit used to measure resistance is the Ohm (Ω).

rest voltage — The voltage of a cell or battery that is neither being charged or discharged.

secondary cell — Secondary cells are electrochemical cells which are rechargeable. The chemical reaction within the secondary cell is reversible, allowing the cell to be recharged many times.

self-discharge — Self-discharge is the tendency of all electrochemical cells to lose energy. Self-discharge represents energy lost to internal chemical reactions within the cell. This energy is not and cannot be used from the battery or cell's output terminals.

specific gravity — Specific gravity is the ratio of a liquid's density to the density of water.

state of charge — State of charge is a ratio, expressed in percent, of the energy remaining in a battery in relation to its capacity when full.

sulphation — Sulphation is the formation of lead sulphate crystals on the plates of lead-acid cells.

Voc — Volts open circuit, usually applied to photovoltaic modules.

volt — The volt is the unit used in the measurement of the electromotive force. A standard electrical definition of the volt is: an electromotive force of 1 volt is necessary to move a current of 1 ampere through a 1 Ω resistor.

watt — The watt is the unit used to measure power. In electrical terms, it is a volt-ampere.

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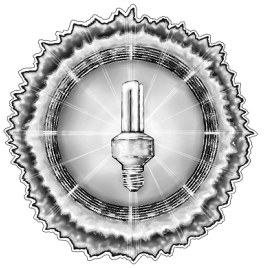
Home Power's Business



"The man who on his trade relies
Must either bust or advertise."
Sir Thomas Lipton — 1870

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Independent Power Providers (IPP)

Don Loweburg and Bob-O Schultze

Things get very busy this time of year. With the good weather comes a "renewed" interest in alternative energy, especially solar. We both agree that things get more hectic every year during Spring, so we know that renewable energy is growing.

Power to the People

First, we want to thank all the members who responded to our survey about ownership, especially the great comments of support. I don't have time to write to you individually, but thanks! Also, I read the letters to the editor and pay attention to the opinions that disagree with IPP. I'd like to make a couple of points as a general reply. We are *not* anti-utility. It's just that this is new territory for them and the rules of the game must be worked out. Because most utilities are monopolies, they can't just be given carte blanche to do everything they wish. We've seen where that leads. The utilities cannot, should not, and will not be trusted with control of our solar resource. There are many ways for the utilities to work in this field, and progress is being made in California and other states. Unfortunately, instead of working with the existing Providers, many utilities have opted for a control strategy and hoodwinked the DOE into financing it. This is what monopolies do. It's beyond their focus to consider anything else but complete control. Country-wide deregulation of the utilities is occurring. Some utilities see the light. As the others are forced to work with IPPs, we'll be happy to lend our support to any forms which benefit all of us. This is about protection for the planet, not profits.

Getting Informed

Solar Energy International (SEI) conducts workshops year round on a wide range of subjects involving renewable energy. In March, they conducted a week-long workshop in Sacramento, California on utility-connected systems. Many of the workshops were technical, covering inverters, batteries, code and safety concerns with grid-tied systems both large and small. Bob-O and Don were invited to present the IPP view. Don spent the latter part of one afternoon presenting many of the points familiar to readers of this column. A good discussion followed. Several of the attendees worked for utilities and there was much agreement about the state of the utility industry. It was a diverse group with participants from other countries in addition to a wide variety of professional backgrounds.Thanks SEI for being open to all the issues around this topic. They are pursuing a very important part in developing the renewables industry, education and training.

IPPs in Action

On April 22, Cynthia and I (Don) went to the Renewable Energy Fair in Arcata, California. The Fair generously provided IPP with space to hand out literature and discuss our viewpoints with interested parties. In addition to talking to folks about IPP, we attended our very first IPP Board of Directors meeting. Besides fulfilling our legal requirements, we had an exciting time planning our work for the coming year.

On our return to North Fork, Cynthia and I made two stops, the first at the new AEE building in Redway, CA. David Katz, the owner, kindly gave us a tour. The building houses all operations, warehouse, offices and production. The entire place runs on a grid-tied PV system with solar thermal water and space heating. Very impressive! Our second stop was at the new Real Goods development in Hopland, CA. The basic site work is complete and building has begun. John Schaefer showed us the model of the completed facility. Stunning architecture and landscaping coupled with daylighting, passive solar heating and photovoltaics will show what is possible for total renewable design. These two projects are commendable and encouraging because they both represent prospering IPP companies serving the renewable energy market (end-users). They serve as indicators of what the future can be. The renewable energy industry is flourishing and we can expect to see many more grid-connected systems.

California Update

There may be some positive changes in the Southern California Edison offgrid program. At a recent meeting of contractors and other interested parties, it was suggested that contractors could bring customers to Edison for financing.

Additional flexibility in system design would be allowed. The feeling was that more flexibility would generate more business. Since those of us in the PV business have access to customers and are more able to design efficient systems fitting their needs, our contacts could have a higher success rate than the proposed systems under the present program. This could be a win-win arrangement. In fact, if the utility is willing to broaden their focus, it is a possibility that the ongrid program

could be run like the offgrid. Edison could provide financing while PV contractors take the lead in customer contact and system design. With customer ownership of the system and net metering, we welcome utility partnership as one of the financiers of PV systems. IPP still stands fast with consumer advocate groups against utility ownership of PV systems on ratepayers' premises. There are many hurdles, but we are cautiously optimistic.

We also want to thank Edison for their active support of the California net metering bill. While several California utilities strenuously opposed the bill, SCE gave Senate testimony in its support. At this time the bill has passed the Senate and is moving through the Assembly. Californians, be sure to write your letters of support! Send letters supporting SB 656 to:

The Honorable Mickey Conroy, California State Assembly, State Capitol, Sacramento, CA 95814 • TEL 916-445-2778 • FAX 916-323-6257.

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Authors: Don Loweburg, PO Box 231, North Fork, CA 93643 • ofln@aol.com

Bob-O Schultze, PO Box 203, Hornbrook, CA 96044 • econnect@snowcrest.net

Code Corner

Example Systems

Stand-Alone and Grid-Tied Systems

John Wiles

This Code Corner will continue the series of examples on the selection of the wiring, overcurrent devices, and disconnects for various types of PV systems. These designs will meet the requirements of the National Electrical Code (NEC). These are examples only and should not be used to define the requirements for any particular system. No information will be presented on sizing the PV array. The array sizes and the loads are used only for illustration. Calculations for a specific system should be accomplished using the methods presented in previous issues of Home Power. The examples in this Code Corner will cover a small residential stand-alone system and a small grid-tied system. The last example in the series will cover a complex residential hybrid PV system with a backup generator.

The systems described below and the calculations shown are presented as examples only. The calculations for conductor sizes and the ratings of overcurrent devices are based on the requirements of the 1993 National Electrical Code (NEC) and on UL Standard 1703 which requires specific instructions in the installation manuals of UL-Listed PV modules. Local codes and site-specific variations in irradiance, temperature, and module mounting as well as other installation particularities dictate that these examples should not be used without further refinement. Tables 310-16 and 310-17 from the NEC provide the ampacity data and temperature derating factors.

EXAMPLE 1 Stand-Alone Residential System
Array Size: 10, 12-volt, 51-watt modules Isc = 3.25 amps, Voc = 20.7 volts
Batteries: 800 amp-hours at 12 volts
Loads: 5 amps dc and 500-watt inverter with 90 percent efficiency

Description
The PV modules are mounted on the roof. Single conductor cables are used to connect the modules to a roof-mounted junction box. UF two-conductor sheathed cable is used from the roof to the control center. Physical protection (wood barriers or conduit) for the UF cable is used where required. The control center, diagrammed in Figure 1, contains disconnect and overcurrent devices for the PV array, the batteries, the inverter, and the charge-controller.

Calculations
The module short-circuit current is 3.25 amps.
UL 125 percent: 1.25 x 3.25 = 4.06 amps
NEC 125 percent: 1.25 x 4.06 = 5.08 amps per module
The module operating temperature is 68°C.
The derating factor for USE-2 cable is 0.58 at 61-70°C.
Number 14 cable has an ampacity at 68°C of 20.3 amps (0.58 x 35) (max fuse is 15 amps).
Number 12 cable has an ampacity at 68°C of 23.2 amps (0.58 x 40) (max fuse is 20 amps).
Number 10 cable has an ampacity at 68°C of 31.9 amps (0.58 x 55) (max fuse is 30 amps).
Number 8 cable has an ampacity at 68°C of 46.4 amps (0.58 x 80).

The array is divided into two five-module subarrays. The modules in each subarray are wired from module junction box to module junction box and then to the array junction box. Number 10 AWG USE-2 is selected for this wiring, because it has an ampacity of 31.9 amps under these conditions, and the requirement for each subarray is 5 x 5.08 = 25.4 amps. Evaluated with 75°C insulation, a number 10 AWG cable has an ampacity of 30.8 amps (35 x 0.88) at 40°F (the J-box temp), which is greater than the actual expected current (125% of Isc) of 20.3 amps (5 x 4.06). In the array junction box on the roof, two 30-amp fuses in pull-out holders are used to provide overcurrent protection for the number 10 AWG conductors.

In this junction box, the two subarrays are combined into an array output. The ampacity requirement for the cable to the control center is 50.8 amps (10 x 5.08). A number 4 AWG UF cable (4-2 w/gnd) is selected for the run to the control box. It operates in an ambient

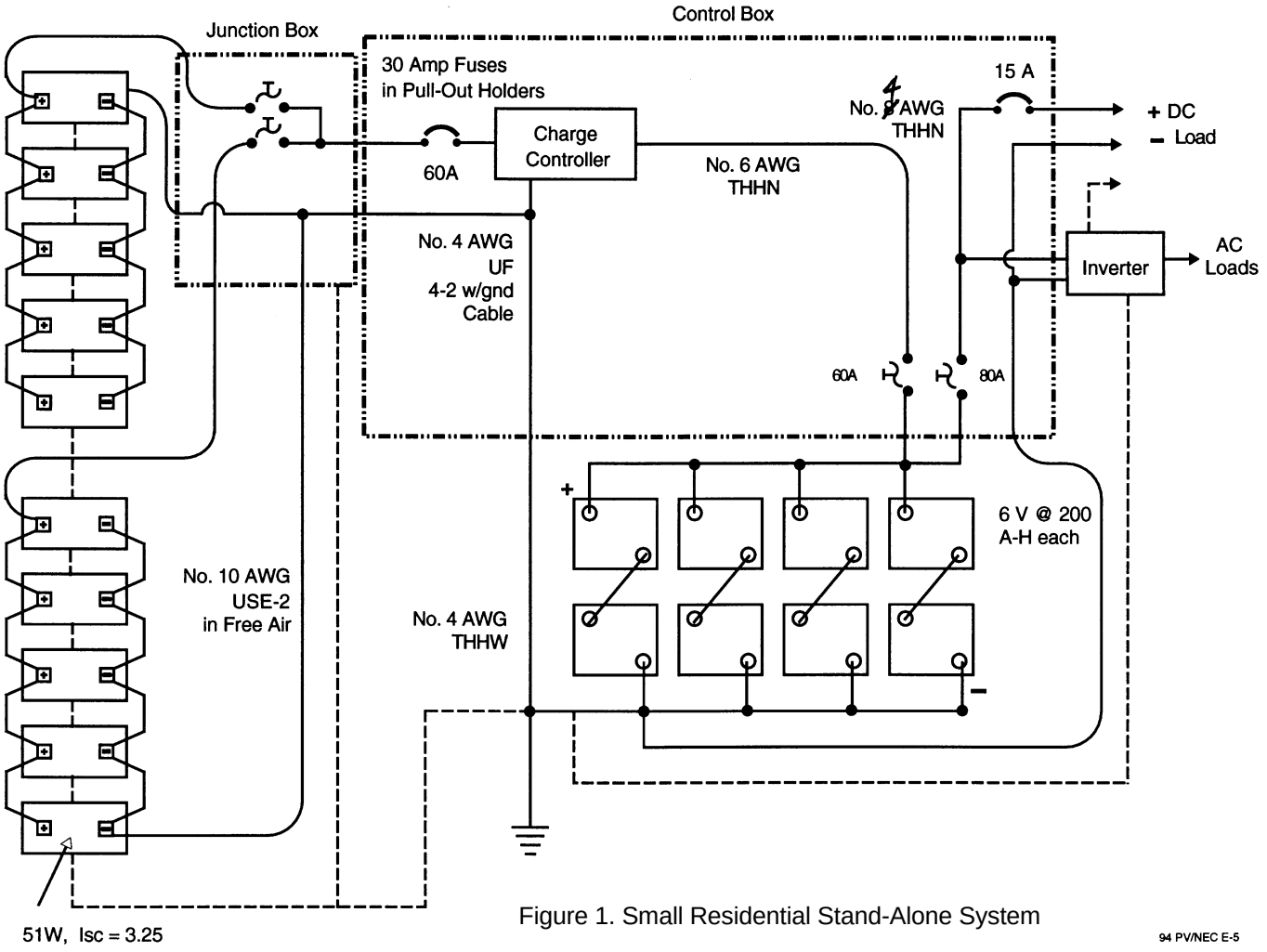

Figure 1. Small Residential Stand-Alone System

temperature of 40°C and has an ampacity of 57.4 amps (70 x 0.82). This is a 60°C cable with 90°C conductors. Care must be used when connecting to fuses that are rated for use only with 75°C conductors.

A 60-amp circuit breaker in the control box serves as the PV disconnect switch and overcurrent protection for the UF cable. The NEC allows the next larger size; in this case, 60 amps, which is over the 57 amps ampacity of the cable. Two single-pole, pull-out fuse holders are used for the battery disconnect. The charge circuit fuse is a 60-amp RK-5 type.

The inverter has a continuous rating of 500 watts at 10.75 volts and an efficiency of 90 percent at this power level. The ampacity requirement of the input circuit is 64.6 amps ((500 / 10.75 / 0.90) x 1.25).

The cables from the battery to the control center must meet the inverter requirements of 64.6 amps plus the dc load requirements of 6.25 amps (1.25 x 5). A number 4 AWG THHN has an ampacity of 85 amps when placed in conduit and evaluated with 75°C insulation at 30°C. This exceeds the requirements of 71 amps (64.6 + 6.25). This cable can be used in the custom power center and be run from the batteries to the inverter.

The discharge-circuit fuse must be rated at least 71 amps. An 80-amp fuse should be used, which is less than the cable ampacity.

The dc-load circuit is wired with number 10 AWG NM cable (ampacity of 30 amps) and protected with a 15-amp circuit breaker.

The grounding electrode conductor is number 4 AWG and is sized to match the largest conductor in the system, which is the array-to-control center wiring and the battery-to-inverter wiring.

Equipment grounding conductors for the array and the charge circuit can be number 10 AWG based on the 60-amp overcurrent devices [Table 250-95]. The equipment ground for the inverter must be a number 8 AWG conductor.

All components should have at least a dc voltage rating of 1.25 x 20.7 = 26 volts.

EXAMPLE 2 Roof-Top Grid-Connected System
Array Size: 24, 50-volt, 240-watt modules, Isc = 5.6, Voc = 62

Inverter: 200-volt dc input, 240-volt ac output at 5000 watts with an efficiency of 0.95.

Description
The roof-top array consists of six parallel-connected strings of four modules each. A junction box is mounted at the end of each string which contains a surge arrestor, a blocking diode, and a fuse. All wiring is THHN in conduit. The inverter is located adjacent to the service entrance load center where PV power is fed to the grid through a back-fed circuit breaker. Figure 2 shows the system diagram.

Calculations
The string short-circuit current is 5.6 amps.

UL 125 percent: 1.25 x 5.6 = 7 amps
NEC 125 percent: 1.27 x 7 = 8.75 amps

The array short-circuit current is 33.6 amps (6 x 5.6).
UL 125 percent: 1.25 x 33.6 = 42 amps
NEC 125 percent: 1.25 x 42 = 52.5 amps

The modules in each string are connected in series. The conductors operate at 63°C. The temperature derating factor for THHN at this temperature is 0.58. The required 30°C ampacity for this cable is 15.1 amps (8.75 / 0.58). Number 14 AWG cable has an ampacity of 25 amps with 90°C insulation and 20 amps with 75°C insulation so there is no problem with the end of the cable connected to the fuse since the 7 amps (the expected maximum current) is below either ampacity.

This cable is protected with a 9-amp fuse.

The cable from the string J-Boxes to the main PV disconnect operates at 40°C. The temperature derating factor for THHN with 90°C insulation is 0.91. This yields a 30°C ampacity requirement of 58 amps (52.5 / 0.91). Number 6 AWG meets this requirement with an ampacity of 75 amps (90°C insulation), and a number 6

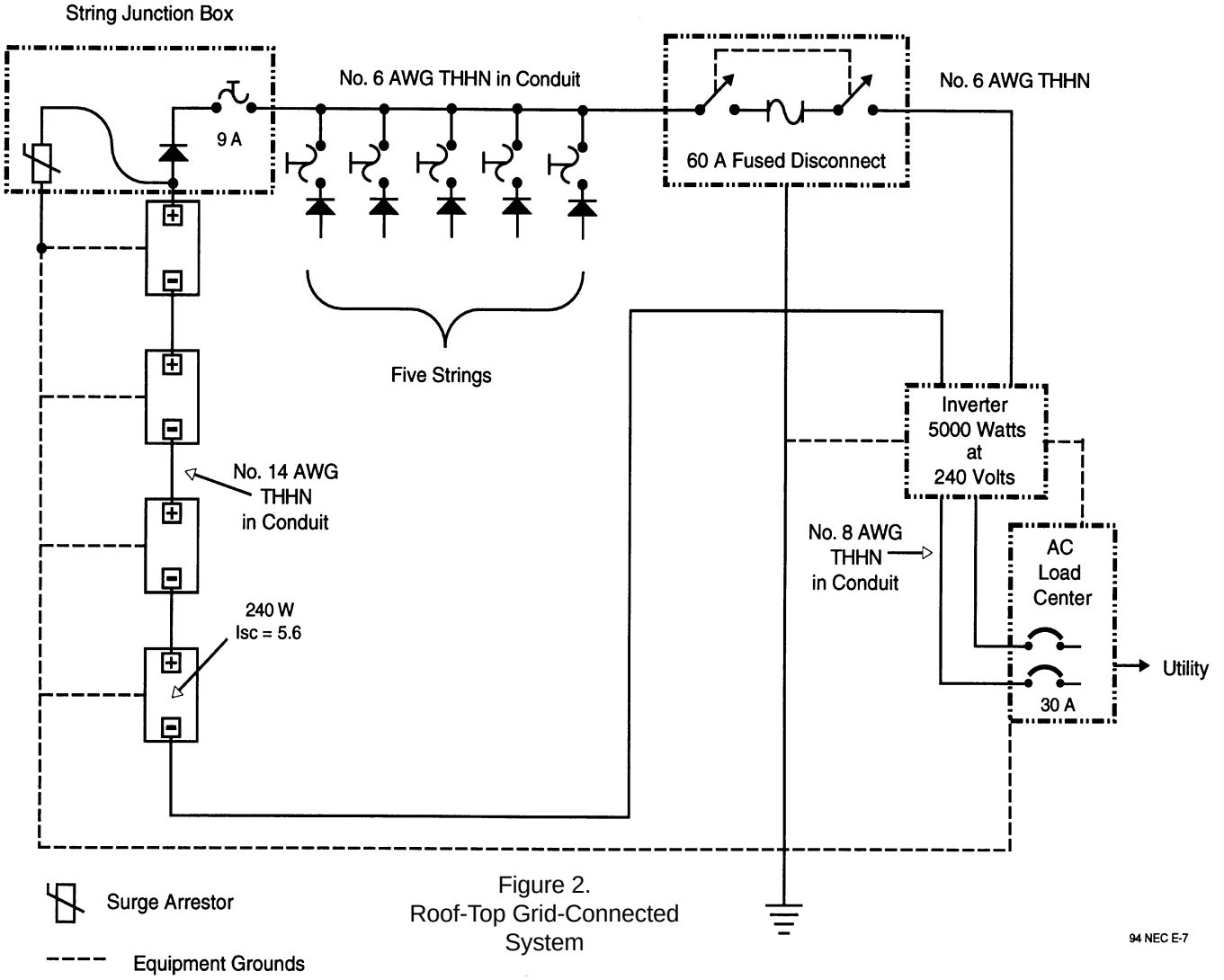

Figure 2.
Roof-Top Grid-Connected
System

AWG cable with 75°C insulation has an ampacity of 65 amps, which also exceeds the 48 amp (42 / 0.88) expected current requirement.

Overcurrent protection is provided with a 60-amp fused disconnect. Since the negative dc conductor of the array is grounded, only a single-pole disconnect is needed.

The inverter output current is 21 amps (5000 / 240).

NEC 125 percent: 1.25 x 21 = 26 amps.

The cable from the inverter to the load center operates at 30°C. Number 8 AWG THHN (evaluated with 75°C insulation) has an ampacity of 50 amps.

A back-fed 30-amp, two-pole circuit breaker provides an ac disconnect and overcurrent protection in the load center.

The equipment grounding conductors for this system should be at least number 10 AWG conductors. The system grounding electrode conductor should be a number 6 AWG conductor.

All dc circuits should have a voltage rating of at least 310 volts (1.25 x 4 x 62).

Summary

The calculations used in these examples are based on UL and NEC requirements. While there is some leeway in the selection of cable types, overcurrent devices, and disconnects, only DC-rated devices should be used. Oversizing the cables will lower voltage drop and increase performance, particularly where long cable runs are involved.

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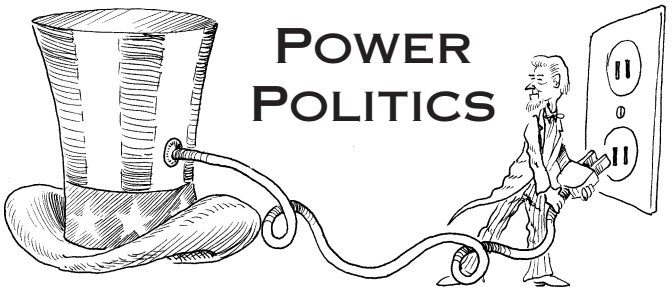
Author: John C. Wiles • Southwest Technology Development Institute • New Mexico State University • Box 30,001/ Department 3 SOLAR • Las Cruces, NM 88003 • Phone 505-646-6105 • FAX 505-646-3841



Rethinking the Power Politics Logo

Michael Welch

When Terry Torgerson first came up with the Power Politics column logo, we thought "This is great!" It conjured up all kinds of appropriate thoughts. Was Uncle Sam unplugging his hat, or plugging it in? Was our government concerned enough about energy to do something worthwhile, or was he preparing to light up the hat and the entire world with coal, oil, and nuclear? Another thing that crossed my mind was the 2-pronged plug and whether that meant that Washington was lacking groundedness. It certainly appears so.

Two particular stories were the final straws that caused me to rethink the meaning of our PP logo. Now I'm fantasizing electrodes on the inside of Uncle Sam's hat, so that when he plugs it in and puts it back on, he will get the electro-shock therapy that may be what it would take to get our leaders thinking straight again. Hmmmm, maybe an electro-lobotomy is the only answer.

I've just been thinking that there was too much unwelcome news in my reports, but I've got to call them as they happen. Unfortunately, I have to revisit a formerly favorable story I told you about last issue because it took an ugly turn after press time.

The first cause of rethinking the logo: I told you about the Mescalero Apaches of Minnesota voting against their "leadership" by reversing the siting of a nuclear waste storage facility on their tribal lands. Their leadership had been wooed by big bucks via the Nuclear Waste Policy Act. Apparently, the vote was not enough to deter the dirty tricks and deceit of the nuclear industry and tribal leaders. According to the Nuclear Information Resource Service, after first agreeing to abide by the vote turning down the dump, it was only a matter of days before petitions were circulating that called for another election. The first election was thought to have been fair, but the second one seems suspicious.

NIRS' Mary Olson confided that the utilities consortium had poured a lot of money into the tribe, and that tribal leadership used their ultimate dictatorial power to overturn the first vote.

The tribal Housing Director has total power over who lives where on the reservation. He personally went door to door with the petitions. Tribal members were intimidated into voting for the dump out of fear for where they want to live. Anyone crossing this person could easily find themselves having to move to a home far away from work or town or even the nearest good road. He made it quite clear that he wanted the tribal members to vote for the dump.

Then there is the payoff factor. The tribe was paid a significant amount of money, with promises that the funds would trickle down to the tribal members. Word was spread that the payoff was $2000 per member. It still remains to be seen whether the money will end up in the hands of the elite leadership or actually find its way to the members.

Either way, the tribe has "voted" and the tally, counted only by pro-nuclear tribal leadership, turns around the previous election. Meanwhile, the Mescaleros are ready to accept nuclear poison from the rest of non-native America, and they have cracked down on local non-native anti-nuclear activists by banning at least two from stepping on Mescalero Apache land. Mescalero activists have vowed to continue fighting the project. We wish them luck.

Some utilities have agreed to drop out of the utility consortium that sought the Mescalero siting in response to their own local activists' cry of "environmental racism," which is defined as the siting of polluting industries in areas where the residents are poor, disempowered and, therefore, unable to adequately fight the siting. These sites are rarely near white and/or wealthy communities.

BUDGET $$ FOR ENERGY TO BE RESCINDED

The second story that really got to me was that Congress's Contract On America has been working on rescission bills to cut current year spending on a wide spectrum of energy projects, with renewable energy (6% - 8.3% cuts) and energy efficiency (6.4%) taking the biggest cuts while fossil fuel (4.8%), nuclear fusion (0% - 4.1%), and nuclear fission (0%) suffered far less damage. The ranges are cuts voted on in the House and the Senate which will go to Conference Committee during the summer to settle the differences.

Current activist thinking is that it is useless to spend much time trying to correct Congress on these rescission bills when hearings are ready to begin on the new annual budget. Now is the time to call your representatives to let them know how much more important renewables and energy efficiency are than the fossil fuels and nuclear. And, if they don't respond appropriately, we just may have to make sure they get one of those fancy new electrified hats.

NET BILLING: INFO = POWER

In the last couple of PP columns, I requested information on which states have net billing programs in place. Thank you to those readers that sent me info on related state and local regulations. It was nice to know that this column is being read!

Since then, I have discovered *two* resources that describe such programs. The first is a brand new publication from Public Citizen, an organization started by consumer activist Ralph Nader. What a great group of dedicated energy activists! The Renewable Energy Sourcebook (not to be confused with any similarly-named Real Goods sales catalogue) is a brand new, state by state book of information designed to be useful to both the seasoned expert and the interested citizen.

For each state, the publication has notes that include whether or not there is a net billing program. The publication is well footnoted with where to get further information and renewable energy contact names for each state government.

Here's an interesting tidbit I gleaned from the report. While it is true that CA has more installed PV than any other state (no surprise there, right?), Washington, DC has more PV per % of state generation and more per capita than any state!

I also found out that only 7 states offer net billing for small renewables producers (MA, MN, NH, OK, PA, RI, TX), only 3 states require utilities to provide off-grid customers who request line extensions with a cost comparison between the line extension and a PV system (AZ, CO, NM), and only one state offers an incentive payment for electricity generated from renewable energy (WI).

You can bet that this publication is going to become a dog-eared and well-used addition to the bookshelf right behind my desk. You also can have a copy by sending $60 to Public Citizen (see Access). They also can sell an individual state's pages from the book for $5 (for the first one) plus $2 for each additional state you want included in the same order. They are willing to negotiate a sliding scale price based on a group's or individual's ability to pay.

The other resource became known to me because in the Renewable Energy Sourcebook, every state I found with retail net billing listed was footnoted to the American Wind Energy Association's "Wind Energy in the U.S. - A State by State Survey" (April 1994). I have not yet seen this report (Hey AWEA, how about sending me a copy!), but it appears to contain a lot of valuable information that encompasses more than wind.

STOP THE CONTRACT ON AMERICA

Newt's devious plan for the U.S. leaves out the poor and disenfranchised, including the environment and, therefore, renewable energy. And it does it all for the sake of increased profits for corporations and the rich. What makes it particularly frightening is that it is being done in the name of a popular movement and by using unfair scare tactics and misnomers.

For example, the main purpose of the Job Creation & Wage Enhancement Act has nothing to do with the title. It provides a 55% reduction in capital gains tax for people with incomes exceeding $100,000 and a 75% reduction for those with incomes exceeding $200,000! This is a blatant effort to help the rich get richer, while we less fortunate taxpayers pick up a larger percentage of the costs of government, especially unneeded military programs.

Even our Congresspeople are running scared. My Congressperson told me that he would have to vote with the committee chair on the renewables rescission (see above) or be removed from his seat on the committee.

You hear so much about a lot of our tax money going to "welfare mothers" and other human resource programs. A reality check shows that about 51% of our income tax dollars fund current and past military projects, with about 29% going to human resource programs. But, the one thing that politicians seem adamant about increasing is also the most expensive: the military!

Just think what we could do for renewables with the

money saved by cutting military spending to a reasonable amount. And just think of what the great minds that are now chained to dreaming up new weapons could do for the environment and the plight of humans!

Right now, the U.S. spends more on defense than the next ten highest spenders in the world, all added together. Furthermore, the combined budgets of ALL countries considered as possible threats to the U.S. totals a measly (relatively) $53 billion, while the U.S. budget hovers around $300 billion. I say this is spending gone mad. The military-industrial complex has gained even greater control than we feared it had in the '70s. Let's give them all the special PP high-voltage Uncle Sam hat.

Did you know that Lockheed Martin's Chairman received an $8.2 million bonus last year? The Pentagon gave his company a total of $31 million in bonuses! This was a government reward for merging Martin Marietta with Lockheed, resulting in the lay-off of 30,000 workers. Now there's a job creation for you.

Since the anti-war protests of the '60s and '70s, we've become aware how the defense industry pulls at our tax pocket strings. Now, the also-powerful industries that pollute and exploit are gaining their own special favors, via the Republican Contract On America.

During the month of May, there were massive protests across the U.S. The people are mobilizing to stop this assault on the poor and middle America. Please, educate yourselves and do what you can to help the growing tide of protest over the Contract.

Against seemingly overwhelming odds, Americans stopped the war in Vietnam. We can do the same here. Yes, the Contract is an assault on us all, and we can stop it so long as we don't remain too complacent.

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Author: Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95521 • 707- 822-7884 voice • 707-822-8640 computer BBS • Internet Email: michael.welch@homepower.org

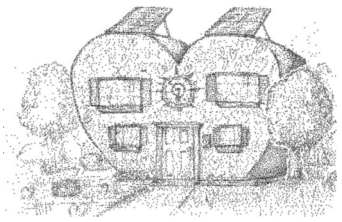
Nuclear Information and Resource Service, 1424 16th St. NW, Washington, DC 20036 • 202-328-0002, Internet Email: nirsnet@aol.com

Public Citizen, 215 Pennsylvania Ave. SE, Washington, DC 20003 • 202-833-3000 x302

American Wind Association, 122 C St. NW, 4th floor, Washington, DC 20001-2109 • 202-408-8988

War Resisters League, 339 Lafayette St., New York, NY 10012

Home & Heart



Kathleen Jarschke-Schultze

With the sunny hours lengthening by the day, my thoughts have turned to outside activities. Gardening and solar cooking mostly. I am building raised beds this year. I have found a cookbook with solar recipes and recipes that utilize the produce of a family garden.

Good Book

The *Morning Hill Cookbook* is the latest literary achievement of Jennifer Stein Barker. She combines a whole foods vegetarian cookbook with short vignettes of her life. Morning Hill, owned by Jennifer and her husband Lance, is so named as it is the first place the sun touches as it rises over their forty acres.

The 9"x6" GBC bound book has 180 pages. Jennifer did the layout and printed the masters at Morning Hill using only solar power. The cover is laminated, a real plus in the kitchen, and the binding allows the book to lie flat. The paper is a light gray recycled smooth stock. It's well made and should last a long while.

This cookbook contains a glossary of terms and ingredients. Assorted garden supply sources (herbs, potatoes, organic supplies, etc.) are listed. A bibliography refers to books quoted or those that have influenced Jennifer's cooking style. These passages are keyed in the text for easy reference. The Index is comprehensive and surprising in variety. A recipe that works in the solar oven gets a little Sun next to the title.

Whole Foods Cooking

Jennifer has a lot of experience in vegetarian cooking. She has taught classes at a local community college extension. She operated a ski lodge that featured her whole foods cuisine. She became quite well known for her creative, delicious and healthy cooking. The only kitchen tools you need are a blender and a beater.

Each recipe is thoroughly explained. Some have variations listed or tips on how to prepare the meal more quickly. It would help to have a garden of your own, but isn't required. The seasons of the garden are reflected in the recipes. There are salads for greens, soups made completely from crops in the root cellar and chutneys from the sweet fruit of autumn. Exotic ingredients are avoided. Dairy products are used, but minimized. It is rare to find a cookbook that encourages you to eat from your garden at every meal.

The bold use of spices makes Jennifer's cooking anything but plain. She actually named the variety of vegetables and fruits used. She explains what qualities make which variety best for a certain dish. I made some changes in my seed list for this year's garden.

Each chapter begins with an excerpt of Jennifer's writing from the *Morning Hill News.* She describes short episodes in her life that have influenced her philosophy and therefore her life and cooking style. I like reading about an author's life. I find I enjoy their books even more, knowing a little about them.

Splendide Washer

Here's some Email on a different kind of washer—it's a dryer, too! "... My wife and I have been following the washing machine articles very closely. We would like to mention another brand of machine that is out there: the Splendide 2000. It is a single-drum washer and dryer.

"The Splendide 2000 is a front loading machine with a horizontal drum manufactured in Italy and runs on 110 vac. Addendums to the owner's manual have been provided by the distributor, Richlund Sales, Inc. They tell us that the unit can wash 12 pounds and can wash and dry 8 pounds efficiently. They also specify that each spin cycle uses 16 amps, with a 19 amp surge to get up to spin speed. The main motor uses 300-900 watts; the dryer element is rated at 1350 watts and is compact (33 1/2" high, 23 1/2" wide, and 22" deep).

"The unit has five different wash settings, five different water temperature combinations, and two temperature settings for the dryer. Water consumption is listed as 12 to 30 gallons. It has a detergent and etc. dispenser drawer. Spin cycle is 1000 rpm. The unit also has a filter on the waste water outlet. This should be good for all of us greywater types. Richlund Sales has a kit for hooking the unit up to a kitchen faucet and an indoor lint trap kit about the size of a shoebox. An extended warranty is also available.

"We will use the unit in our apartment as we prepare to move onto our land. We haven't used it yet; we will follow up with our experiences as we have them. It was reasonably priced, looks well made, and the distributor was very nice. It got here, from Kentwood, LA to Houston, TX, in three days by truck..."

Here's another Email. "... I also fell in love w/ the idea of getting an ASKO. It sounded great but the washer alone was way more than the washer/dryer set for the White-Westinghouse. I don't mind paying more for an appliance (I own a Sun Frost) but the WW seemed as good as the ASKO. I bought the WW and it works

great. I generally run it off the generator because the pump runs directly off the generator. Most importantly, I have run it off a Trace MSW (modified-sine wave) inverter without problems! Hot water for the washer comes via an Aquastar."—Carolyn

Conclusion

I am still receiving a lot of commentary on washers for RE and energy conscious on-grid homes. I have found the washer that fulfills my particular needs very well (see Things that Work! in this issue). Within the next two years there will be several more choices of H-axis washers from the main appliance manufacturers. Hopefully, with more models on the market the price will come down a bit without losing the quality of the few models on the market today.

Access

Kathleen Jarschke-Schultze is enjoying the Spring at her home in northern-most California, c/o Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-0830 Internet Email: kathleen.jarschke-schultze@homepower.org or kjs@snowcrest.net

Morning Hill Cookbook, Jennifer Stein Barker, Morning Hill, HC 84 - Izee Route, Canyon City, OR 97820 $11.95 PPD

Richlund Sales, Inc., 7695 Hwy 1053, Kentwood, LA 70444 • Phone:504-229-4922 • Fax: 504-229-4956

HAPPENINGS

AFRICA
The 1995 ISES "In Search of the Sun" Conference, "The World Solar Energy Exhibition" and the finish of a solar car race is scheduled for September, 11–15, 1995 in Harare, Zimbabwe. For exhibitor and attendance info contact Peter Armstrong, exhibitor director, In Search of the Sun, POB 2851, Harare, Zimbabwe; Phone: (263-4) 730707, Telex: 0907 (26623 ZW), Fax: (263-4) 730700, e-mail: xcarelse@zimbix.uz.zw

CANADA
The 7th Canadian Hydrogen Workshop will be held June 4–6, 1995 in Quebec, Canada. Workshop topics are: Hydrogen production, usage, storage, safety, environment, fuel cells, and metal hydride rechargable batteries. For more information contact: Canadian Hydrogen Association, 5 King's College Rd, Toronto, Ontario M5S 1A4; Fax: 416-978-0787.

The "Alberta Sustainable House" is now open for public viewing every Saturday 1:00 PM to 4:00 PM free of charge, with Grand Opening scheduled for July '95. The first of its kind in Canada, the project emphasizes cold-climate state-of-the-art features/products based on the founding principles of occupant health, environmental foresight, resource conservation, AE, recycling, low embodied energy, self-sufficiency, and appropriate technology. Already in place: R17 window, multi-purpose masonry heater, solar hot water, greywater heat exchangers, LED and electroluminescent lighting, solar cookers, and others. Under development: hydrogen fuel cells, Stirling co-generator, Tesla bladeless steam turbine, and others. Contact: Jorg Ostrowski, Autonomous & Sustainable Housing Inc/Alternative & Conservation Energies Inc, 9211 Scurfield Dr NW, Calgary Alberta T3L 1V9, Canada; 403-239-1882, Fax: 403-547-2671.

The Institute for Bioregional Studies was founded to demonstrate recent ecologically-oriented, scientific, social and technological achievements that move us toward ecological, healthy, interdependent and self-reliant communities. Among 1995 Summer Programs are: July 2-16, Permaculture Design-self-reliance, growing food and building creative, beautiful energy-efficient structures from local materials; and July 31 - August 3, Hands-on, Homemade Power and Energy Conservation-solar home design, straw-bale building construction, composting toilets, composting, energy conservation, greywater treatment and appropriate technologies. For more info: IBS, 449 University Av, Charlottetown, Prince Edward Island C1A 8K3, Canada; 902-892-9578.

The 2nd World Hydrogen Summit in Montreal, September 28 - October 1, 1995 will be presented by The International Council on Cooperation & Development of Hydrogen and include "Hydrogen & Ecology '95 Workshop." The exhibit portion will be part of the largest business show in Canada, with more than 30,000 visitors. For exhibitor and attendance info contact Hydrogen Industry Council, 1800 McGill College Av #2610, Montreal, Qc Canada H3A 3J6; 514-288-5139, Fax: 514-843-6079.

FRANCE
13th European Photovoltaic Solar Energy Conference and Exhibition, Nice, France, 23–27 October 1995. For more info contact Dr. H Ossenbrink, EC-Joint Research Centre, European Solar Test Installations/ESTI, 1-21020 Ispra (VA), Italy; Phone: 39-332-789 172, Fax: 39-332-785 561 or 39-332-789 268. For proceedings of the 12th Conference write: H.S. Stephens & Assoc, Pavenham Rd, Felmersham, Bedford MK43 7EX, England.

NATIONAL
Electric Vehicle Challenge 1996, The Charge Across America is planned for June 16-28, 1996 and will run from Washington, DC to Los Angeles. Entered vehicles will take 13 days to travel over 2700 miles. Within the run, special events will take place in Indianapolis IN, Tulsa OK, and Phoenix AZ. Entry registration closes January 15, 1996. For info, contact EVC Headquarters, 12 Cedars, Freeman, MO 64746; 816-899-5511, Fax: 816-899-5430.

Energy info on the Internet can now be accessed via the Energy Efficiency and Renewable Energy Network (EREN), a multimedia WWW server developed by the DOE. Check it out at http://www.eren.doe.gov or contact: Energy Efficiency and Renewable Energy Clearinghouse, POB 3048, Merrifield, VA 22116; 800-363-3732; e-mail: ENERGYINFO@delphi.com

"Learning to be Water Wise and Energy Efficient" curriculum with materials for classrooms and home schools is now available from National Energy Foundation, 5225 Wiley Post Way #170, Salt Lake City, UT 84116; 801-539-1405, Fax: 801-539-1451.

American Hydrogen Association Bulletin Board System: Solar Hydrogen BBS, 415-494-3116, 1200–14,400 baud V.32bis. V.42bis 8N1; also, Prosperity without Pollution: AHA Tempe BBS 602-894-8403.

Energy Efficiency and Renewable Energy Clearinghouse (EREC) is offering info for people who would like to cut their energy bills at home or business: free booklet-"Heat Pumps"; free packet-"Lighting"; free packet-"Wood"; and free info on home energy audits (call). Contact EREC: Phone: 800-DOE-EREC (363-3732); mail: EREC, POB 3048, Merrifield, VA 22116; e-mail: energyinfo@delphi.com; TDD: 800-273-2957; BBS: 800-273-2955.

ARKANSAS
Sun Life is now conducting "Third Saturday Seminars" on inexpensive building techniques. Their focus is to teach home building from materials that can last a thousand years and cost less than conventional wood-framing. These are hands-on, all-day workshops. Contact Loren at POB 453, Hot Springs, AR 71902.

ARIZONA
The State of Arizona is now offering a tax credit for installation of all types of solar energy systems. A solar technician certified by the Arizona Department of Commerce must be on each job site. For more info contact ARI SEIA; 602-258-3422.

Beginning June 5, Mohave Community College, Colorado City, will offer an 8-week course on solar energy and its uses taught by Charlie Collins of the Do It Homestead. "Common sense" classroom study will be paired with field trips to working water pumping, hydro, sun and wind power systems. For further info and registration contact: Don Timpson, Director, Mohave Community College, 602-875-2799; or Charlie Collins, 801-877-1061.

CALIFORNIA
SMUD's 1995 Brown Bag Solar Series VII. Where: SMUD Energy Services, Plaza 50–2, Conference A (upstairs), 6701 4th Av, Sacramento, CA. When: Every other Tuesday, Noon to 1:00 pm. Bring your lunch and enjoy the FREE presentation! June 13 - Building With Rice Hulls/Solar Water Heated Floors; June 27 - Solano Wind Project Update. For more info or to borrow a video of past presentations call 916-732–6835.

Solar Cook Off at the Rodeo Grounds in Taylorsville, July 8, 11AM-dusk. Food, solar demonstrations, EVs, music-7 bands plus evening dance. Call Blackhawk Solar: 916-283-1396.

Siemens Photovoltaic Training Workshop, intensive five-day seminars, will be held July 10–14 and October 16–20. For more info contact Cindy Vernon, Siemens Training Department, 4650 Adohr Lane, Camarillo, CA 93010; 805-388-6585, Fax 805-388-6395.

Electric Vehicle Workshops will be given in Fort Bragg, July 12-13, September 23-24, and November 18-19. Topics covered include design, components, maintenance, safety, and many others. Contact Burkhardt Turbines, 1258 N Main St, #B2B, Ft Bragg, CA 95437; 707-961-0459.

Renewable Energy Development Institute-REDI Conference '95: PVs and EVs-California Leads the Way, August 11–13. Three main topics: Utility Deregulation-financing, effects on RE, and REDI '93 followup; EV Marketplace-fleet operators meet EV manufacturers, financing, and insurance; National Labs-National Technology Transfer Center and Federal Lab Consortium will provide info on the range of tech advancements of over 750 national laboratories (such as NREL, Argonne, Sandia, Lawrence Livermore) and potential commercial applications. Contact REDI, 733 S Main St #234, Willits, CA 95490; 707-459-1256, Fax 707-459-0366.

California Air Resources Board (CARB) is doing "routine, continuous review" of the 1998 ZEV mandate (2% of cars sold must be EVs) and holds forums, usually at their Mobile Source Division, Annex IV, in El Monte. Dates and subjects: June 28-Consumer Marketability (and potential barriers); July 12-Infrastructure (such as building codes, emergency response, recharging sites, quick charging); August 9-Hybrid Issues (revised treatment under the regs); September 13-Fleet Issues; September 28-Board Hearing (proposals for "LEV regulatory clean-up items"); October 11-Technology Review

(focus on batteries, incl. staff and industry presentations); November 8-Benefits and Costs of EVs (incl. staff presentations). Contact: Air Resources Board, 2020 L St, Sacramento, CA 95814; 916-332-5840.

COLORADO

'95 Jade Mountain/Denver Electric Vehicle Council Electrathon™ Challenge Schedule: Electrathon Challenge '95 events will be held the third Sunday of the month. Vehicle inspection will begin at noon with competition starting at 1:00 pm. The future is electric! Join the fun at the next Electrathon. June 25th, 12:00–3:00, 33rd and Arapahoe, Boulder, CO. July 23rd, 12:00–3:00 6th Ave and RD93, Golden, CO. All event locations are tentative. August 27th and September 24th locations to be announced. For more information call Bill Williams 303-449-6601 or write DEVC, 2940 13th St, Boulder, CO 80304

1995 Sun Sprint of the Rockies is an electric, hybrid and solar/electric vehicle race. For its inaugural year, the race will be run from Aspen, CO to Moab, UT crossing some of the world's most beautiful scenery during the days of July 11–21, 1995. All contestants must be present on July 10, for the pre-event technical testing in Aspen. On the morning of the 11th we will begin the 550 mile road trek to Moab, UT, with at least 14 educational shows open to the public. The course will include steep mountain passes, low flat lands, and twisting canyon roads to challenge the vehicles. We will average about 50 miles per day, each with mid-day recharging. This will be a fun filled time for both the public and the racers. It will also be very educational for the racers as well as the public. For more information please contact Zach Keele at 303–872–3882, fax 303–872–2390, or write to him at 81438 Hwy 92, Maher, CO 81415.

Wind Power Workshop, August 14-25, Carbondale. The first week combines classroom instruction with actual set-up of residential-sized wind generators. The second week will be spent installing a complete residential system. Contact Solar Energy International, PO Box 715, Carbondale, CO 81623, Phone 303-963-8855, Fax 303-963-8866.

The 6th Crestone Energy Fair, Labor Day Weekend, September 2nd and 3rd, 1995, Crestone Town Park, Free to the public. A gathering of solar advocates, experts, and novices for a weekend of solar technology, fun, music, food, council and a tour of solar homes. This is a self organizing solar potluck and camp. Come and enjoy. Booth fee — 1 item donation to the Green Goods Raffle. Turtle Island, PO Box 222, Crestone, CO 81131.

Solar Energy International (SEI) is offering workshops on the practical use of solar, wind, and water power. The 1995 Renewable Energy Education Program (REEP) features one and two week workshops: Solar Home Design , Environmental Building Technology, PV Design & Installation, Advanced PV, Solar Cooking & Biofuels, Micro-Hydroelectric Systems, and Wind Power. Guest speakers and professional instructors will teach the design of state-of-the-art solar homes that are self-reliant, energy efficient, healthy to live in, and earth-friendly. Participants will learn the knowledge and skills to build energy-independent homes with solar, wind, and water power. The series is for owner-builders, industry technicians, business owners, career seekers, and those working in developing countries. The workshops may be taken individually or as part of a program. The cost is $400 per week. Scholarships and work/study programs are available on a limited basis. Contact: Solar Energy International, PO Box 715, Carbondale, CO 81623 or call 303-963-8855.

Visit the new National Wind Technology Center operated by the National Renewable Energy Laboratory, just outside of Golden. Facilities assist wind turbine designers and manufacturers with development and fine-tuning and include computer modeling and test pads. Call in advance, 303-384-6900, Fax 303-384-6901.

MASSACHUSETTS

The Seventh Annual Sustainable Transportation and S/EV95 (Solar & Electric Vehicle) Symposium, Boston, MA, November 13-15, 1995 (exact location to be announced) will bring together a broad coalition of transportation planners, electric and hybrid electric industry representatives, business people, policy makers, and engineers to foster the growth of a viable electric vehicle industry, and the development of a sustainable transportation vision for the nation. In-depth workshops, concurrently held sessions and an extensive trade show have made the event the major electric vehicle conference in the United States. For more information contact: NESEA, 50 Miles St, Greenfield, MA 01301, 413-774-6051, fax 413-774-6053.

MICHIGAN

Great Lakes Electrathon(TM) Association will hold a race June 10, 9:15AM, at Michigan Ideal Speedway in Springport. Students from 35 Michigan high schools will race, and then there will be an open competition. The Association can be reached at POB 224, Sparta, MI 49345; 616-887-2744, Fax: 616-887-7755.

Cedar Valley Workshops and Seminars,. Traverse City, MI will be holding week-long workshops in renewable energy technology during the summer of 1995. Workshops in superinsulated construction (June 18–25), solar heating (July 9–15), wind power (July 23-August 5), and photovoltaics (August 13–19) will be offered, For more information contact Dr, Conrad Heins, 215 E. Muskegon St., Cedar Springs MI, Phone (616) 696–0603.

MINNESOTA

SOLAR '95 Conference - 10,000 Solutions: Paths to a Renewable Future will feature the 24th American Solar Energy Society Annual Conference and the 20th National Passive Solar Conference. Billed as the largest and most comprehensive solar energy conference. 140 presentations chosen in a rigorous review process will emphasize applications of solar energy that can improve the nation's economy, that address cold climate challenges, transportation technologies including buses and a boat regatta, high and low temp solar thermal, K-12 education, wind, PV, architecture, international programs and app's, utilities and demand-side management, glazing, electro conversion, fuels and chemicals, solar processes, NREL's resource assessment and other design tools, and sustainable communities. Workshops are offered on several of these subjects. Speakers and workshop directors are leaders in solar research, university programs, and commercialization efforts, including: Paul Gipe, Nancy Hazard, Paul Maycock, Steve Strong, Elliott Bailey, Steve Dess, Mary Jane Heinen, Ken Olson, Doug Balcomb, Randy Swisher, Neville Williams, Donald Aitken, Horace McCracken. July 15–20, 1995 in Minneapolis, MN. Coincides with the Aquatenniel festival celebrating the city's 22 lakes and 153 parks served by 45 miles of walking/biking paths. For brochure contact: American Solar Energy Society, 2400 Central Ave #G–1, Boulder, CO 80301, 303-443-3130, fax 303-443-3212

MISSOURI

The US Department of Energy, NREL, and Crowder College Missouri Alternative and Renewable Energy Technology (MARET) Center are sponsoring the nation's first solar powered bicycle race, June 19, 1995 on the Grand Prix race course at the Indianapolis Raceway. Solar BikeRayce USA is open to high schools, vocational schools and other secondary educational institutions. A solar powered bicycle is a pedal-powered bicycle that uses an electric motor, batteries and solar panels for added power. Riders use a combination of muscle power, solar energy and stored energy. To win, the team's best athlete must ride the solar bike to achieve the highest speed by optimizing their use of human and the bike's electrical energy. The first 60 schools submitting proposals will participate in the race. Entries will be split into two divisions: teams with a male rider and teams with a female rider. The winning team from each division will receive a trophy and a $1,000 cash award. Second & third place finishers from each division will receive trophies and $600 and $400 respectively. Applications & regulations are available from: Solar BikeRayce USA, Crowder College MARET Center, 601 Laclede Ave, Neosho, MO 64850, 816-899-5512.

NEW YORK

The New York State Electric Auto Association (NYSEAA) is dedicated to sharing current electric vehicle technology. Monthly meetings, for date and location call Joan at 716-889-9516

OHIO

Solar electric classes taught at rural alternative powered home with utility backup. Maximum of 12 students. Must advance register. $30 fee per person, $35 per couple, lunch provided. Class will be full of technical info, system sizing, NEC compliance, etc. Students will see equipment in use. Dates: June 10, July 8, Aug. 12, Sept. 9, Oct. 14, Nov. 11, & Dec. 9. All classes held from 10 AM to 2 PM on Saturday. Call 419-368-4252 or write Solar Creations, 2189 SR 511 S, Perrysville, OH 44864-9537.

The Great Lakes Electric Auto Association's mission is to contribute to the freeing of the US automobile market from dependency on petroleum through advancements in electric and hybrid/electric technology. For more information contact, Larry Dussault, GLEAA, 568 Braxton Pl E, Westerville, OH 43081-3019, 800-GLEAA-44 or 614-899-6263, Fax 614-899-1717. Internet address: DUSSAULT@delphi.com

OREGON

The Lost Valley Educational Center is an intentional community and learning center devoted to developing the skills and awareness that will create a sustainable lifestyle. They are

offering various low-cost workshops covering everything from low-cost underground housing to building solar ovens. For more information call or write Lost Valley Educational Center, 81868 Lost Valley Ln, Dexter, OR 97341, 503-937-3351

TENNESSEE
A Solar Fair with booths and demos will be held September 22nd in Legislative Plaza, Nashville, in conjunction with the 5th Annual Harvest Festival. For information, contact: The 5th Annual Harvest Festival, Box 259, Summertown, TN 38483, Phone 615-964-2590.

VIRGINIA
Seminars at Bear Mountain Outdoor School include Passive Solar Design, July 7-9; Alternative Energy Resources, July 14-16 and 16-21; and Active Solar Design, September 15-17. Contact Bear Mountain Outdoor School, US 50, Hightown, VA 24444, Phone 703-468-2700.

WASHINGTON
GreenFire Institute offers resources and info on staw bale construction including Build-a-Complete-Home Course, 7 weekends August-October, Whidbey Island. Contact the Institute at 1509 Queen Anne Av N #606, Seattle, WA 98109; Tel/Fax: 206-284-7470, e-mail: pegrobs@aol.com

WISCONSIN
Model Home Electrical System Workshop: Help install the PV and wind generator systems that will power this year's Midwest Renewable Energy Fair in Amherst, WI. Instructors for the PV installations will be Jim Kerbel of Photovoltaic Systems and Chris LaForge of Great Northern Solar. Instructor for the wind generator installation will be Mick Sagrillo of Lake Michigan Wind & Sun. The workshop runs from June 15th to the 22nd, and is limited to 12 people. Cost is $125, payable to the Midwest Renewable Energy Association, PO Box 249, Amherst, WI 54406. For more information, call Jim Kerbel at 715-824-2069.

The Sixth Annual Midwest Renewable Energy Fair will be held June 23–25, 1995 at the Portage County Fairgrounds, in Amherst, Wisconsin. Contact Midwest Renewable Energy Assn., PO Box 249, Amherst, WI 54406 • 715-824-5166

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for U.S. ZIP codes only, see page 81 for international back issues.

(Sorry, we're out of issues 1 through 10, #12 , #15 and #36). We are planning to compile them into a book. Until then, borrow from a friend. If you have a computer (or a friend with one) download the article you're missing by calling the Home Power bulletin board at 707-822-8640. Or check with your local library; through interlibrary loan, you can get these back issues. Jackson County Library in Oregon has all issues as does the Alfred Mann Library at Cornell Univ.)

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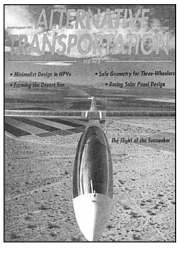

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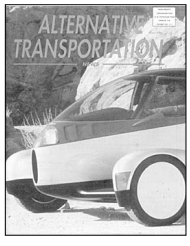

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the Wizard speaks...

From Perception To Self

Perception is the basis for our entire existence. Our lives are grounded in the perceptive process. Perception is, however, only one side of a greater process leading to synthesis. Synthesis defines the unique viewpoint of the Self. The transition from perception to synthesis consists of four stages. These are data, information, pattern and paradigm.

Data arises as a result of assigning symbols and symbolic values to perception. When the set of symbols and values called data is arranged in various forms and structures and examined from various viewpoints, a set of hypotheses called information is developed. When enough data is developed into information, patterns begin to emerge. As individual patterns develop and converge, there begins to arise a definitive world view. The out growth of this world view is the emergence of a paradigm or unified viewpoint.

The final stage is the synthesis of various paradigms from a multiplicity of disciplines. This synthesis leads to an understanding of the Self and its relationship to the rest of existence. It also results in an enhanced arena of perception as the unfolding of the potentialities of the Self begins.

Letters to Home Power

Yucky to Ducky
My wife and I live on 85 acres in Central Ohio (about 2/3 of the way from Columbus toward Zanesville). Our house is either timber frame or post & beam (I'm not sure which). It's over 150 years old. My neighbor, who rents 65 acres for farming, tells me his grandmother was born in this house. He's over 60. We have spring water, pumped in from outside, and hot water heat.

A few months ago I decided to install a couple of steel beams to help support the floor joists, which are hand-cut oak about 7 inches x 8 inches x 15 feet on thirty-inch centers and sag a little after 150 years. In order to install the steel beams, I had to have some heating pipes re-routed. I asked the plumber to install a check valve (avoid backflow from heating system into house water) and to install anti-corrosion fluid. He did a great job, but forgot the check valve. The water in the spring was blue for a week—an indication of anti-corrosion fluid—and the house water was contaminated.

We were unaware of what happened until Shari was doing laundry and added some chlorine bleach to the water, which immediately turned brown and ruined the clothes. I flushed the entire system including the heating system. Still, when bleach was added to a glass of water, after about an hour, a half-inch layer of yellow water would appear in the bottom of the glass. No one could tell me how to resolve this. We lived with it about 5 months, buying bottled water.

And then, voila, I bought HP#45. There, in black and white, was the water heater article (page 30). The magnesium anode I removed looked like a combination of #5 and #6 in the article. I ordered it for $17.50 and installed it. My water now passes the chlorine bleach test. I feel the corrosion fluid sucked the life out of the old anode. Anyway, a happy ending. I want to subscribe. Charles Payne, Thornville, OH

Hi, Charles. We're very happy you solved the problem and pleased as punch to have helped. Your letter is a good reminder for users of hydronic heating. Keep thermal system fluids separate from domestic water systems. Complex systems, like our homes, survive by attention to detail. Little items like the hot water heater anode can make big differences in performance. Chumps, like your plumber, can also make a big difference. The anticorrosion fluid used by your plumber was probably ethylene glycol. It is commonly used to freeze-proof RV water systems during winter storage. It is relatively safe, but I have no idea what happens when it is mixed with bleach. Richard Perez

Check into the eco-logic of using chlorine bleach. If you are using a septic system or a greywater system, then bleach is bad news for your beneficial microbes. If you're feeding the city sewers, then we really don't need any more chlorine loose in our environment. There are effective substitutes for chlorine bleach. Try air drying on the solar-powered clothes line, letting sunshine bleach your clothes. Or borax is a benign whitening agent. Both Amway™ and Shaklee™ offer other alternatives to bleach. Rubbing Ivory™ soap directly on heavily soiled areas or stains plus soaking will work for lots of stuff including grease, ballpoint pen and blood. A favorite stain/mildew remover (diluted, it's a disinfectant) is Citrasolv™, available at natural food stores. Donna Worden

Have PV, Will Travel
The arrival of our bi-monthly issue of *Home Power Magazine* is a major event at our house. As alternative energy users, we are interested in what other AE users are doing and how they are doing it. Aside from reading the latest news from RE users across the country, our ultimate "high" has been visiting RE homes, which quickly brings me to the point of my letter.

For us, the perfect road trip is planned around the addresses of other RE users. To stop for a few hours, a day or even overnight. To see first-hand how others have solved their own unique off-the-grid problems. To share solutions and trade ideas. I wonder how many other *Home Power* readers feel the same way? Suppose one were planning a trip from central Missouri to eastern Idaho via Kansas, Colorado, Wyoming and Montana. Wouldn't it be great to access a source for information regarding RE homes along the way? This could provide directions, info on what electric and water systems are in use, whether the visiting RE user could camp for the night, how much advance notice the homeowner needs, etc.

My husband, Jerry and I have been using AE for 20 years. Our system has evolved from Jerry using a car battery for lights to the bank of PVs and wind charger we use today. The system grows and changes as we implement plans for the future. We have many interests, but AE is the focus of our lives, and we enjoy sharing our experiences.

I read, with interest, Kathleen's column a couple of years ago when she suggested a plan that RE users might spend a period of time at another RE home while the owner was away for some reason or other, and wonder what kind of response she got from that? I also wonder if my road-tripping idea has been suggested before and if someone has implemented it? If not, I would like to, if the interest is there. I have the experience, knowledge and software to maintain a database of this type, and it would be fun!

See you in Wisconsin in June! Kathleen, if the Columbine seeds Jerry brought you last year didn't grow, let me know, I'll bring you a plant. Brenda Leap, Window Rock, Rt 1 Box 71,Tunas, MO 65764

Do I hear a volunteer, Brenda? Response to Kathleen's idea, while not large in number, was entirely positive. Your idea is even better and should have even wider appeal. We've printed your access data here so others may contact you if they are interested. Richard Perez

The Same Sun Shines On Africa (only more of it)
On behalf of my fellow comrades in R.E.T.I., I wish to

congratulate you for becoming the champion in feeding Uganda with all the up-to-date information in solar technology. We are greatly honored for your great job over there, especially for the article you put in your *Home Power* magazine issue #43 of Oct/Nov 1994 whereby be have found ourselves being recognized by your company. It was submitted by our great instructor, Mr. Mark Hankins, of the Karadea solar training facility. He has given us the courage to campaign for solar technology expansion throughout Africa. Thanks, dear friends, for publishing his article. We hope it may attract the attention of our States to recognize solar technology in the same way they see grid power. It may reduce taxes for solar equipment, thus increasing the ability of the poor to use free energy from the sun.

Our company, Renewable Energy Technology International (RETI), has this goal. We promise that, with clear guidance, we shall start getting these magazines whenever they can be availed. We shall also be sending in articles. We unite with you to form a very strong and interesting hands-on journal. I would like to wish you success in your publications. All from Charles Lutalo, heading RETI Technical Team, Kampala Office, c/o Suzan Muwanga, POB 4798, Kampala, Uganda.

Hello Charles. We are pleased to hear that your program is doing well. Please keep whatever monies you have for Home Power *subscriptions. It is our pleasure to send you (and others in developing nations) free issues of* Home Power*. Use the money to buy another PV module, or to promote your solar education programs. Richard Perez*

SOLosophy

I would be hard pressed to "not like" anything about HP. I have great respect for your integrity and commitment to giving us tools to use—as we choose. We need not agree, only respect each other and have the courage to deal with our faults and the intelligence to recognize our successes. Our RE system grows, fails, succeeds, and lives through our changing demands and our attitude toward it. It reflects who we are and the way in which we relate to it. HP is a bimonthly "gotcha" when my attention and energy have flagged and I've forgotten to adjust my panel angle or check my electrolyte. It is my access to new products and ideas and stimulates me to never assume I already have the answer—I'm still working on the question. Moby Wile, Bellvue, CO

We are all still working on questions rather than answers, Moby. Our perception of energy is constantly changing. Karen and I have been off-grid since 1970. You might think we'd have our act together, finalized and polished. Instead you'd find our systems in a constant state of change. Components designed with massive oversizing five years ago are suddenly too small. We are now powering more equipment than ever. We currently cycle between 6 and 13 kWh daily from PV and wind. Better than 75% of this energy goes down the throats of the computers we use to publish Home Power*.*

Lately, I've slipped into the habit of thinking of our system as "the grid". This means that I recharge smaller systems (like our electric tractor and our water supply system) with surplus power from our main system. During the last month (lots of sun and wind), we've even taken to recharging the electric tractor at night (when it is resting and we are too). We use a 120 vac Statpower battery charger powered via an Exceltech inverter. We are essentially recharging the ET's batteries from the main system. I would have discarded this idea as hopelesssly devious and inefficient ten years ago. Now it fits transparently and waste-free into our operating environment. Here is a realization: Once an RE system is installed, the only way to waste its energy is not to use it, the opposite of conventional conservation thinking. The more I learn, the more I realize I don't really know diddly. Welcome to wonderous confusion. Let's explore together. Richard Perez

Remember Your Library

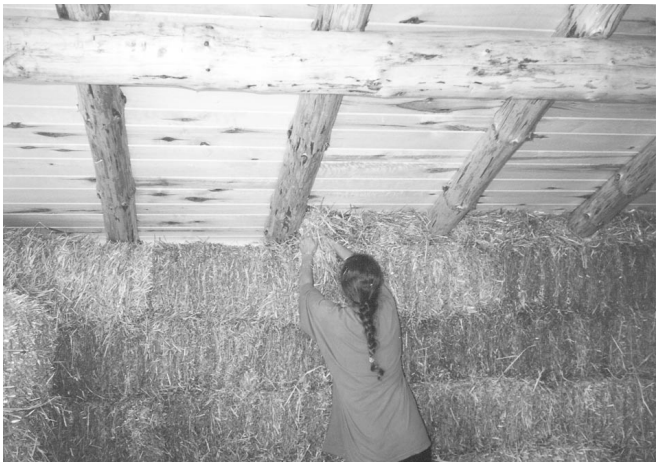
Enclosed is a check for a gift subscription to *Home Power* for our public library. I would encourage other readers to do the same. It's how I found out about *Home Power*. I have since gone off-grid. I sure appreciate some anonymous past donor. Ron Breckon, Ellensburg, WA

Thanks for encouraging me, Ron. We've been meaning to do an "Adopt a Library" deal for years now. This seems like the perfect chance to start. Here's the deal for any Home Power *Subscriber. Contact the library of your choice. Ask them if they would place a free copy of* Home Power *on their shelves. This is a necessary step since some libraries are overloaded (we don't want* Home Power *thrown out with the junk mail). If your library is agreeable, we will split (50/50) the cost of the library's subscription with you. Please provide the complete, official address of the library and be sure to mention the "Adopt a Library" deal when you order. Access data for ordering is on page 81 of this issue. Richard Perez*

Strawbale in Minnesota

I've all issues incl. #1! The changes! I appreciate the balance you are beginning to bring to your mag—small/simple and large/complex systems. I still believe the key to everything is mindful planning. I'll trade money (or the consideration of it) for time any day. Please renew my sub!

Cheryl Valdis and I built a shop out of straw bales (see photos) this past summer—fairly efficient. I still prefer our earth tempered (underground) space for energy efficiency. Pics enclosed. Peace y'all. Bruce Brummit, Ponsford, MN



Hi, Bruce. Thanks for the flowers. I remember meeting you at the 1990 Midwest Renewable Energy Fair *five years ago—see you at this year's fair! Richard Perez*

Hydrogen Exchange

I am writing from Bristol in the United Kingdom. I regularly read your magazine which is a very valuable source of information and inspiring ideas! I am looking for some contacts in the USA and I wonder whether you may be able to help, either through contacts you may already have or by publishing a portion of this letter in a future issue.

At present, I am a Lecturer in Math and Physics in a College of Further Education in Bristol. I also help run the Pure Energy Trust, a registered charity. Our aim is to publicise the use of hydrogen as a domestic or vehicle fuel. We gather information from around the world regarding current research. We are trying to raise funds for a small demonstration project to set up in the UK. This would utilize windplant electricity in an electrolysis unit. It would produce hydrogen for a suitably modified IC-engine vehicle.

Last year I began a part-time Ph.D. research degree with the Open University here in the UK. The potential advantage of hydrogen as an energy store and pollution-free combustible fuel are well known. Still, much research is still required to refine the technology required to generate and store the gas in an efficient and safe way. My work to date has been theoretical in nature, there being no R&D hydrogen projects underway in the United Kingdom.

As I will be in the States this summer, I would be very interested to visit any hydrogen projects or installations during my stay. I would be interested in schemes of all sizes, whether home constructed for domestic use, or large research projects used for detailed scientific study. Indeed, if there were a positive response, I could then collate all the information, which could be made available for current or new users of hydrogen technology.

I would be very grateful if you could assist me in this venture. My visit to the USA will be in Aug-Sep this year. If your readers or contacts are willing for me to visit their projects, I can be contacted at the address below, either by post or by phone (not on the internet yet!). If they were to send me some brief details by post, I will contact them in July to arrange details, times, etc.

Many thanks for any help in advance. I hope you find the enclosed project of interest. I would certainly welcome any comments you may have on the issue of hydrogen technology. I look forward to future correspondence, yours sincerely, Ben Lane, 37 Cornwallis Crescent, Clifton, Bristol BS8 4PH, United Kingdom, Phone 44-0117-973-2986

Hello, Ben. I've printed your access data and hydrogen fans can contact you directly. There are two people you must arrange visits with while you are in the USA. Contact Dr. Peter Lehman of the Schatz Solar Hydrogen Project at Humboldt State University in Arcata, California 95521 • 707-667-0306. Contact Walt Pyle in Richmond, California at 510-237-7877. Both of these fellows are deeply into hydrogen. Peter does R&D on a large solar hydrogen electric project (see HP#22, pg. 26). Walt's hydrogen installation is also solar-powered and is used for thermal and electric applications (see HP#39, page 32). Peter and Walt both build PEM fuel cells. Richard Perez

It's a Gas in Illinois

I hope this gets to you after all the weather problems the West Coast has had lately. (I knew there was a reason I stayed in the Mid-West!) *Home Power* #45 is the first time I have seen your magazine. My question may not fit in with your renewable energy ideals but is about being "off grid".

I have inherited my parents' retirement home in far south/central Illinois. After about a year of visiting and exploring, I have found that the water well is, in effect, also a natural gas well. It is not a high volume well, but I have put together a self-regulating system that has kept a scrap water heater burner assembly burning with a half-inch flame for the last six months. (Yes, the water system still works fine.)

Now, what do I do with this free flame? I am looking for an external combustion 110/220 volt electrical generation system. (IC systems are too noisy and vibrate too much. Also, I am not sure of the purity of the fuel.) Any ideas? Can anybody point me in the right direction? The ideal system would have a closed loop for the working fluid and be able to pump the fluid approximately 50 feet for condensing so the "waste heat" could be used for space heating. I feel from my calculations that I should be able to get a continuous 1.5 to 2 kW. Maybe even 3 kW. I do have enough Mechanical Engineering background to to cobble up a system. But the same background tells me I may be able to buy the trials, tribulations and experiences of someone else. I do not want to re-invent the wheel if I do not have to.

By the way, I am not the only potential customer/builder/client. The local water well contractor tells me that, until his father and he started installing submersible pumps, well pit "pops" (small explosions) were quite common. He says it is common for wells in the area to put off "swamp gas." When I told a co-worker about my little project, he said that in his home area in West Virginia, it was common for people to have a mini open-pit coal mine on their property. Every day or two, they would take a wheelbarrow and a pick to obtain some heating/cooking fuel. It seems to me that if they are burning free fuel for heat, they should be able to make electricity in the process.

While your solar/wind power ideals are great, the fact is that most people in this country are “on grid” and used to it. Even if they in theory could, they won’t go “off grid” if the nuisance factor is too high. I am one of those people. I am looking for something no more complicated than ‘60s automotive technology, i.e., the KISS (Keep It Stupidly Simple) factor.

On the way to my folks’ place, I see hundreds of solar-heated hog houses. The idea was unheard-of 30 years ago (the Sixties ???) but they are just A-frames with clear fiberglass on the south side. It has been shown to work and is hard to do wrong. Can we do it again? I’ve long been a Michael Hackleman fan and will subscribe now that I know where he is published. Keith Saxe, Ingleside, IL

Hello, Keith. The simplicity of technology should really be judged by its application and sustainablity. For example, the average 1960 automobile was far more complex and less reliable than a high-tech PV module. The smarts and complexity of the PV are built-in at the factory. Application is simple, reliable, and maintenance free. The same cannot be said for yer average 1965 Olds. I think the best way to turn your gas into electricity is a thermoelectric generator (TEG). These beasties are close cousins of the PV except—they are powered by heat instead of light. The only moving part in a TEG is hot gas—they are semiconductor devices. See Steve Willey’s article (HP#36, page 47) for the scoop on TEGs. Normally I won’t recommend them. They’re relatively inefficient and consume expensive fuel. But you’ve got free gas, so rock and roll. The only other options involve conversion or fabrication of an engine which burns “swamp gas” (a mix of methane and other -anes). Engines contain moving parts—this means maintenance and short device life. I suggest skipping the heat to mechanical conversion and go directly for heat to electricity. Richard Perez

Reader Network?
Please find enclosed $$ to renew my subscription. Question—is it possible to access other “in-state” subscribers to your magazine (reader sub service—as with Utne Reader)? How about a box we could check off releasing our names/addresses? If so, here’s mine. We need to capitalize on local interest/enthusiasm to propel ourselves faster away from old fossil ways (thinking and policy). Thanks for the contribution in this great endeavor of connectedness and spirit, working towards a cleaner/more sustainable future.

As for my part, I’ve been off the grid (except for a few brief job-related relapses) for 25 years now, living in my own home-built houses (like on hay wagons). My battery banks (120 VDC & 12 VDC) are all made up of used marine batteries (free from a nearby marina). Despite many of the submitted systems you’ve published, I intuit and empirically feel that “small is beautiful.” Simplicity has many (unsung) merits. These can act as very strong guidelines as world (and US) population keeps growing uncontrollably, creating more consumerism and more pressures and stresses on an already over-stressed and abused planet. How hard is it to espouse simple joys and simple pleasures?

Sorry for the handwritten letter (haven’t got a low-power laptop yet). Keep up the good work. Radkin, 218 Harbor Rd, Shelburne, VT 05482-7006

Hi, Radkin. There can be no question that we possess the knowledge, technologies, and consciousness to use RE big time on this planet. The blocks are ignorance and a lack of political will. Education and networking will handle the first, and courage and tenacity the second. Michael Hackleman

Correction and Direction
Regarding your story on the Sun Frost RF-19 in the Feb/Mar 95 issue of HP, I would like to comment.

Talking about the compressors, you wrote: “one for the freezer and one for the freezer.” Also, in your discussion, you failed to note if, and if so how many times, was the refrigerator opened during the “test” days. This would reflect in energy costs relating to loss of cool air from door opening to regain of set temperature by running the low energy compressors. How well would this work in a busy household full of kids or a commercial kitchen? Would the compressor have to work all day to maintain a marginal temperature?

Thanks for the great magazine. How about stories on alternative building materials like they use in Europe, like “Isochanvre by Chenovotte Habitat” in France? They mineralize hemp, add lime and water, mold it, then build with it! *NO TREES!* Very cool!!

Here’s another renewal check!! I always check my label. Good idea. Does it work? Alan Silverman, Santa Rosa, CA

Hello, Alan. Sorry about the typo, sometimes we get tired and mistakes slip by us. The Sun Frost RF-19 uses one compressor for the frig and a second for the freezer. The Sun Frost we tested is in our kitchen. It is under normal use by three to four hungry humans. We open the frig door at least a dozen times daily and the freezer door at least twice daily. Our freezer compressor has a duty cycle of less than 50% except during the warmest summer weather—freezer temperature is always around zero F regardless of the ambient temperature. Check your mailing label is working great, only less than 20% no reup. Richard Perez

Back Issues ARE Available
Gentlemen *(sic):* I am a new subscriber and I have just received issue #42 with the index for issues #1-#41. I don’t know how it is I never heard of your magazine until a reader of “Solar Today” mentioned you in a reader response note. Nevertheless, I, as well as I’m sure many others, am very disappointed to learn that all back issues are not available.

A suggestion. “Backwood Home” magazine has made available books/compilations of articles from their back issues. Can you to do something similar? I’m certain there would be quite a demand for this. Otherwise, I would appreciate any info/suggestions on access to unavailable issues. Is there perhaps a library in my vicinity or a club that may have them? Thank you, A. L. Barberi, Santa Clara, CA

We’re glad you found us, A.L. Do you have, or have access to, a CD-ROM computer drive? Back issues #1 - #35 are available in this format. Or try inter-library loan from California’s state-wide library system. As far as books/compliations, there no telling what the HP Crew will pull out of their magical hats and monstrous computers… Donna Worden

Absence Makes the Heart Grow Fonder
I didn't really think that I would miss you. My sub expired. After reading and rereading the copies of *Home Power* that I had, I DO MISS YOU. Enclosed is a check for another year. Also, I want all the copies I am missing that may be available. I have issues 32, 33, 34, 35, 36, 37, 38. I have enclosed a SASE. Please let me know what is available.

Because of your magazine, I now have battery mowers, solar panels, battery banks and am working on a wind generator. Thanks for the past articles, and I do look forward to the future. Thanks. Robb LaBrenz, Linwood, Michigan

Check the ads, Robb, on ordering back issues and the CD-ROM! And we're glad you're back with us! It's the sign of a good relationship to have a gnawing feeling in your gut until you figure out that something vital is missing. I relish each issue when it gets to me. Everything *waits until I'm satiated. Michael Hackleman*

Viva Green Architecture!
I think your magazine is great! I'm a recent architecture graduate. I'm interested in "green" (environmentally friendly) architecture. I see it as salvation from much of the environmental woe encroaching on every last natural area of Earth. People could live with so much more free time if we didn't have to work to keep our heat on! I had wished I could find a magazine devoted to renewable energy. I never thought I'd stumble across one on my trip to Oregon! I'm glad this magazine is around! Andrea Montalbano, Huntington, NY

Welcome aboard, Andrea. Even today, I see new buildings constructed with little regard for solar orientation, passive heating & cooling measures, and low energy consumption. Retrofits can be expensive or compromised by these early decisions. Architecture and energy are intimately related. Both modern and ancient examples abound to show the many recipes one may follow. Lloyd Kahn's Shelter *is one I pull out often! Two important questions: How many square meters of solar energy will a building "absorb" daily? And, at 1kW per square meter input, how will I channel that energy in beneficial ways? Let your imagination fly. Michael Hackleman*

***Home Power*'s Father's Day Honoree**
Enclosed is my renewal check. My daughter, Betsy Bartel, sent me a gift subscription. You put out a very nice magazine and I've enjoyed every issue.

Betsy lives in the mountains northwest of Ft. Collins, Colorado. She is off grid. Ever since she built her own house, she has asked me a bundle of questions about photovoltaics, remote generator start, wiring, etc. Over the last few years I've helped her wire her house for AC and DC, and last September watched her activate her PV system. She has done most of the real work. My contribution was constructing the charge controller and DC distribution circuits in two steel boxes 8"x10"x3". There have been no problems with the system after five months of operation.

My main interest in HP are the "how-to" articles with schematic diagrams. Also, what works and what doesn't work. I do a lot of construction of electronic projects—everything from code practice oscillators to kilowatt amplifiers for amateur radio. Although I'm over 70 and retired from Bell Telephone Labs in New Jersey, I still don't seem to have any more time for construction than I used to have. There is too much out there I haven't tried yet! Since age 15, I have been a licensed ham. My present call is W2LQ. My two areas of activity are 20 meter SSB and QRP cw operation. I have been a licensed professional engineer in Texas since April 1953 although I don't do work that requires a license.

Electric vehicles have always fascinated me. I hope to own one some day. Your articles are appreciated. I'm sending today for the *Convert It!* book from Electro-Automotive in Felton, California. Have a nice day. Baity Bartel, Denton, TX

We are having a nice day, Baity. The copy flows, the machines hum, the bird makes juice, the array catches photons, the cats nap, and there's a blend of rainforest music and blues around me as I edit. Michael Hackleman

Paper Prices and Raptors
Dear Karen, I agree with your article about paper prices in the new Home Power (#46), and I'll pay extra for HP. I'm saving money by reducing other paper usage—for example, I buy the newspaper less often, and I buy books on computer CDs now — and I will gladly put some of those savings into paying a little extra for *Home Power.* Your magazine is about the best use for paper I can think of, and I can understand if it takes you longer to get around to distributing HP on disk since many of your readers probably do not have computers.

Another article in the current HP surprised me. I didn't know windmills hurt raptors. When I lived on a homestead in Humboldt County California in 1979, my experience showed otherwise. We were constantly having red tail hawks and bald eagles take our baby chicks, geese, ducks and even lambs. There was nothing we could do to make these raptors go away. But when we installed a windmill, the raptors miraculously vanished. They'd immediately return any time the windmill was not working. Clearly the windmill was driving them away. Hard for me to believe that raptors could be attracted to windmill farms.

The hawks and eagles especially went for our baby chicks. There was a big drought and grasshopper infestation then, and we'd put the chicks in our vegetable garden to control grasshoppers, which would have destroyed the vegetables. The chicks reduced grasshopper damage in the garden, and the only real side effect was that when they'd grow up and become hens, they'd try to get back in the garden to eat the vegetables instead of the grasshoppers. Having the raptors eat our chicks was a real problem.

Then I noticed the eagles and hawks were only taking chicks that were certain colors. When I'd buy the chicks, I'd take a few of each color. The chicks that were wiped out by the raptor had a color that was different from the color of the ground. I stopped buying any chicks the raptors would go for, and the losses have stopped. Indeed, these birds of prey don't have such good eyesight.

The eagles, I've noticed, fly much closer to the ground than the hawks when stalking prey. Locals say that red tail hawks have better eyesight than bald eagles.

Recently, a dead bald eagle (broken neck) was found by the

side of a road near Eugene, Oregon. The Fish and Wildlife Service said it was probably killed by smashing into a power line while dive bombing after prey. These kinds of things do happen. Even airplane pilots have trouble seeing things from mid air—that's why high tension power lines in some places have big colored balls on them.

The HP article mentions some possible reasons why the big centralized wind farm near Livermore attracts and harms raptors: that the wind farm is becoming the area's only place left with rodents (the raptors' main food) or that the raptors are becoming disoriented by toxic pesticides in their diets.

Another source of toxic pollution that could be affecting the birds of prey in that area is the petrochemical industry. Dr. Samuel Epstein writes in his landmark book *The Politics of Cancer* that people in the San Francisco Bay Area have a much higher cancer incidence rate than other US cities because of toxic pollution from the area's intensive petrochemical plants. A lot of plastic products are made in Livermore. For example, next time you're in Costco, go to the trash bag section and read the fine print on the box. All of the plastic trash bags Costco sells are made in petrochemical plants in Livermore, CA.

It's good to read that this problem of raptors being hurt by hitting windmills does not occur on individual windmill sites. Keep us informed. Get the word out that this is not a problem at homesites with windmills. While centralized wind farms are better than nuclear and coal plants, better yet is decentralized power production as detailed in *Home Power* magazine.

Please don't stop publishing! We need the information you disseminate. This is the best use of paper I can think of. Sincerely, Carlos Portela, 3-D Software, pcsolar@usa.net

Thanks, Carlos, for saving trees. I love them, too. At this time, each HP *nearly fills a 1.2GB diskette (including color). It may not be too long before this much data is commonly handled on a desktop or laptop. Interesting to hear your jenny was a "scarehawk." I recently purchased several pens and a roll of food wrap all made with corn oil plastic. Donna Worden*

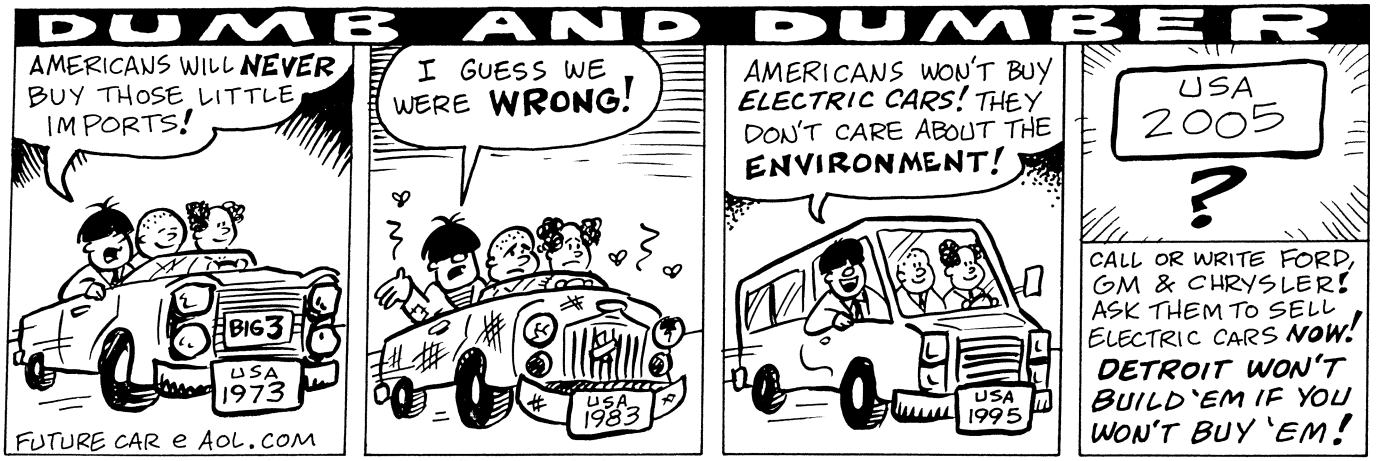
Handling the Change

Dear Karen. Thanks so much for the article. I support your price increase even though I buy it at the newsstand. I showed it to my 14-year old daughter, and she cut it out to take to her homeschooling group. Keep up the good work! Mark Coleman, coleman@laplaza.taos.nm.us

I think most Home Power readers know what a good deal they're getting—at any price. That the subscription rate can be as low as it is for what goes out the door, all the better. The HP crew is interested in increasing the average person's savvy in RE topics. It's been said, "After all is said and done, more is said than done." I figure it helps to know when someone is trying to wrap you up in a snowball. It's just as nice to know when they're not*. This way, you'll know from whom to buy equipment. Michael Hackleman*

Thought for the day

"All life is a risk. If you want more life, risk more ..."



Writing for *Home Power* Magazine

Home Power is a user's technical journal. We specialize in hands-on, practical information about small scale renewable energy (RE) systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your RE experiences printed in *Home Power.*

Informational Content
Please include all the details! Be specific! We are less interested in general information, than in specific information. Write from your direct experience—*Home Power* is hands-on! We like our articles to be detailed enough so that a reader can actually apply the information. Please include full access data for the makers of equipment mentioned in your article. *Home Power* readers are doers. They want access data for the devices and products you mention in your article.

Article Style and Length
Home Power articles can be between 350 and 6,000 words. Length depends on what you have to say. Say it in as few words as possible. We prefer simple declarative sentences that are short (less than fifteen words) and to the point. We like the generous use of Sub-Headings to organize the information. We highly recommend writing from within an outline. Check out articles printed in Home Power. After you've studied a few, you will get the feeling of our style. Please send a double spaced, typewritten copy if possible. If not, please print.

Editing
We reserve the right to edit all articles for accuracy, length, and basic English. We will try to do the minimum editing possible. You can help by keeping your sentences short and simple. We get over three times more articles submitted than we can print. The most useful, specific, and organized get printed first.

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You can send your article via modem to either the HPBBS at 707-822-8640 or via Internet. HPBBS address is: richard perez • Internet address is: richard.perez@homepower.org

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Q&A

12 VDC Lighting

Dear Therese Peffer, I've read two of your articles concerning 12V lighting. You seem to be well informed on the subject. One article closed with a sensical statement to the effect that not all lights fit all applications, and this is my reason for writing: To ask your advice and if newer products have superceded your earlier findings.

I am replacing auto taillight type fixtures in a trailer in which I intend to live full time. The quality and usefulness of lights are important to me as is conserving my battery.

My first area of concern is the portion of the trailer where I read, write and draw. My thinking is that Tek-tron's RV-12, 13W fluorescent light will be a good choice for illuminating that general area. Perhaps the 12V halogen light will make a good reading and writing lamp, at least in cool weather. I'm not convinced it will suffice for drawing and other close work. Right now I use a 120V drafting lamp with a color-corrected bulb or a 120V combo fluorescent/incandescent drafting lamp.

When this trailer is finally as I wish it to be, it will be electrically free from the grid in all modes. At this time I do not have an inverter, and storage is but one 12V marine battery. I have a ways to go, but I've chosen to be with what exists. In time I will have an inverter (my microwave and vacuum cleaner demand it) and greater amp hour capacity as well as some quality batteries. At that time, my work light needs will be solved. However, I will retain an interest in efficient energy use and seek to implement the best products available.

In advance, thanks for any note you send. Use my enclosed envelope. Jim Wirth, Carlsbad, CA

Hi, Jim. Therese has left Home Power *to pursue a career in Architecture at the University of Oregon, Eugene, but I'll answer your question. The Tek-tron 12 VDC fluorescent light is very high quality and you are right—the perfect choice for area illumination in your trailer. Halogen incandescent lamps are available in a variety of sizes (wattages), so finding one that is appropriate for a reading lamp should be easy. The color correct drafting lamp is another matter. Almost all lighting technologies have an inherent color bias. Incandescent lamps tend to have higher light output in the longer light wavelengths (red and yellow). Fluorescent technologies produce more light in the shorter wavelengths (blue). This is why your color correct drafting light uses both lighting technologies. You can duplicate the effect of your drafting lamp by combining the light of a 12 VDC halogen and a 12 VDC fluorescent. You can balance the color by moving each light source either closer to or further from your drafting table. I suggest that you contact S&H Alternative Energy Products, RD3 Box 312, Putney VT 05346 • 802-722-3704. S&H specializes in custom built low voltage lighting. They could make a color correct 12 VDC drafting lamp for you if you don't want to make your own fixture.*

If you already had your inverter, then I would recommend a 120 vac Osram EL-15R compact fluorescent. This compact fluorescent has bright, full spectrum light and a built-in reflector to concentrate the light on your drafting table. We use these Osram reflector lights at all the workstations here at Home Power*. They run great on all types of inverters. They are very efficient and start immediately. They produce only miniscule electromagnetic pollution (no radio interference and below 2 milliGauss magnetic fields within two feet of the lamp). Richard Perez*

Short Wave Radio Power

Dear Karen or Richard, I am looking at the C. Crane Co. catalog as I type you this short note. I am going in the next few months to purchase a short wave radio. I have not as yet decided which kind. I am however, very interested in other alternative sources of power for it.

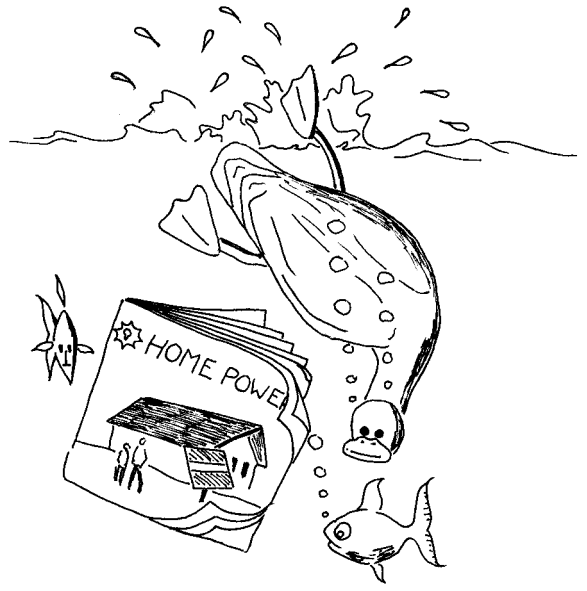
I am looking at the MSX-10Lite 10 watt photovoltaic panel. I need something like it that converts solar power into electricity. I spend a lot of time in the field without any possibility of regular electrical power. Will such radios as Radio Shack work with other sources of energy? Please advise as to the quality when comparing the radios from C. Crane Co. and the larger (12") ones from Radio Shack. Everette W. Pouncey

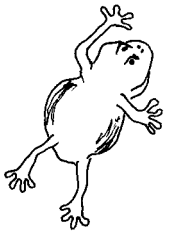
Hello, Everette. The MSX-10Lite is more than capable of powering a shortwave receiver. And this could be a problem. Since most receivers operate on between 6 and 9 Volts DC, you will need a voltage regulator if you want to directly power the radio with the PV module (which is rated at over 16 Volts DC). The regulator is easy to build from Radio Shack parts (see HP#40, pages 104–106 or HP#38, pages 32–36 for the schematic). If you don't want to build your own regulator, then you can buy one ready made from C. Crane ($15.95 shipped free) or Radio Shack. They both offer regulators that accept 10 to 20 VDC as input and output a choice of 4.5, 6, 7.5, or 9 Volts DC. This regulator will allow you to power the shortwave receiver directly from the PV panel. Only problem now is that the radio only works when the sun is shining.

All portable shortwave receivers can be powered by replaceable batteries, including the Radio Shack models. For a specific example, I have a Sangean 803-A, an AM/SW/FM receiver sold by C. Crane. This radio is powered by six D sized flashlight cells and two AA sized flashlight cells. The six D cells (in series to make 9 Volts DC) power the radio, while the two AA cells keep the radio's memories alive. The six D cells provide weeks of intermittent listening and the two AA cells last about a year keeping up the memories. The best setup is to buy two complete sets of rechargeable cells for whatever radio you choose. I recommend NiCd cells; they will give you better service than most other commonly available types. Discharge one set of cells in the radio while you are recharging the other set from the PV module. See HP#36, page 78 and HP#19, page 18 for descriptions of recharging small NiCd cells from small PV panels. This way you will always have power for the radio, even at night, inside a room, or during long cloudy periods. You can also use the PV recharging setup to recharge NiCd cells for your flashlight.

I rate the quality of C. Crane's radios very highly and their customer service is outstanding (call for free catalog 800-552-8863 • FAX 707-725-9060). My Sangean is almost four years old and still works like new. C. Crane will sell you the same radio as Radio Shack for less money. And C. Crane offers radios whose performance surpasses the best that Radio Shack sells. For example, they sell a hot Grundig Satellit 700 model that already contains the above-mentioned regulator and will recharge its internal NiCd cells directly from the MSX-10 PV panel. Shipping is included and there is a 30 day no hassle return policy.

I started fooling around with radios when I built a 120 vac powered regenerative receiver (all tubes) at age ten. I can still remember the 1958 Motorola AM portable pocket radio I saved for months to buy. It had three transistors and ate 9 Volt batteries like peanuts. It received my local AM radio station (WHEB in Portsmouth, New Hampshire) within about ten miles of the station. I soon tired of WHEB's programming, but the wonder of portable radio stuck with me. I am a ham (N7BCR) and I've tried many kinds of receivers over the years. You can spend over a thousand bucks on a fancy shortwave receiver, but the truth is that most models in the $200–$300 range will work as well and also consume less power. What really counts is the antenna. Big antenna means big signal. Plan on taking a portable wire antenna with you (C. Crane sells a nifty roll-up model for $13.95). String it out when you are stationary and just about any receiver will work well. Richard Perez





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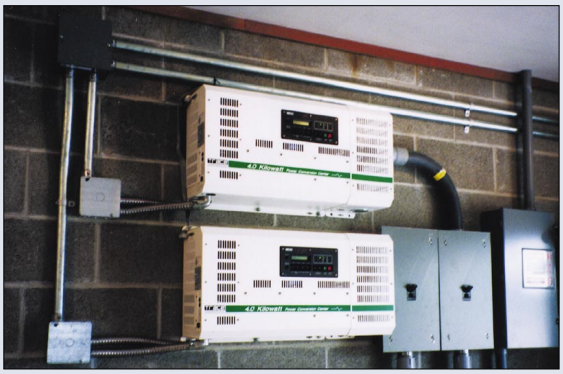

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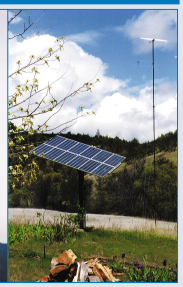

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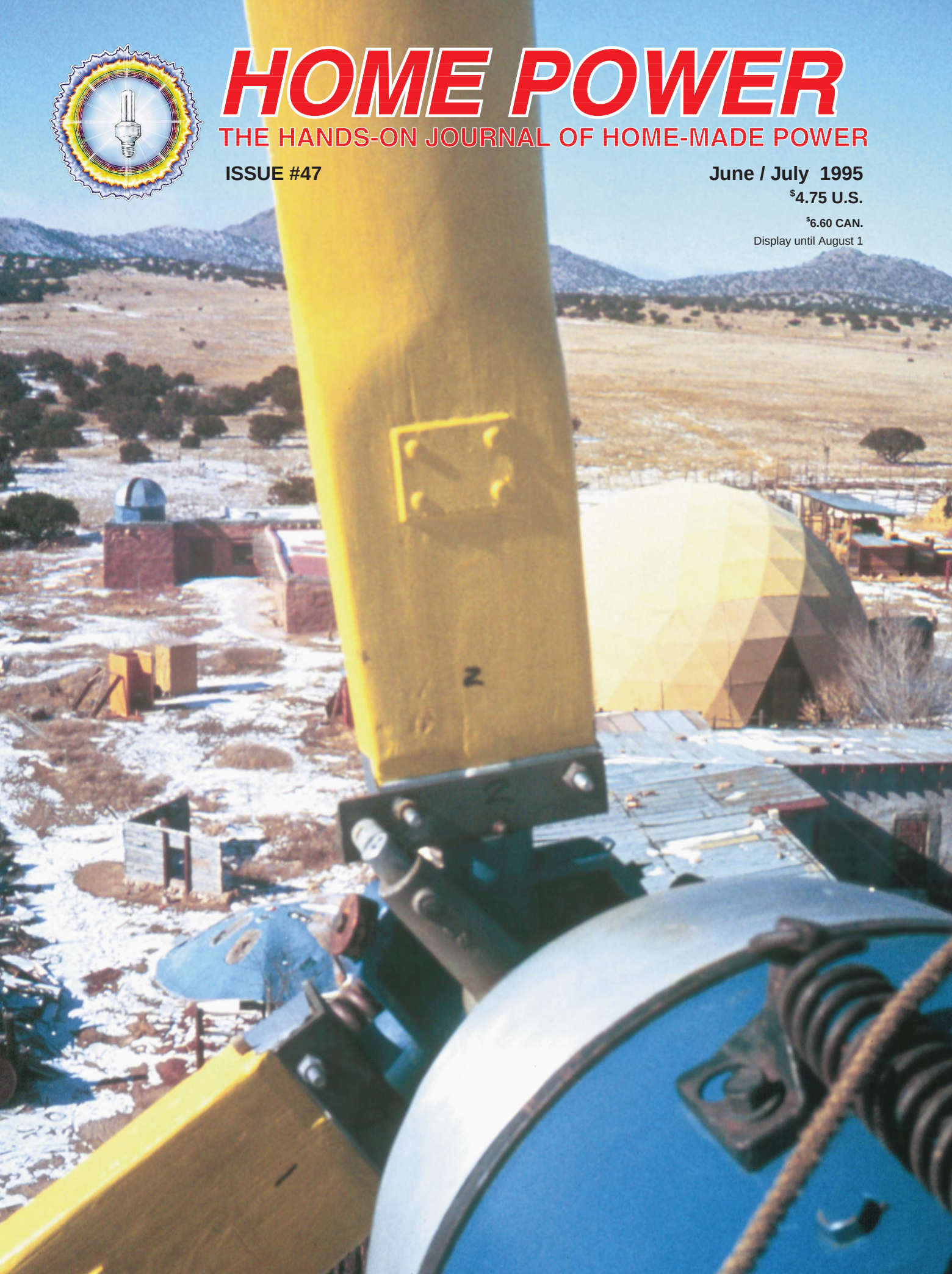

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